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OF

CIVIL ENGINEERS

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(INSTITUTED 1852)

VOL. XLVIII— o. I.

JANUARY, 1922

Edited by the Secretary, under the direction of the Committee on Publications.

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* The Standing Committees had not been appointed at the time of going to press with this number of *Proceedings*.

Vol. XLVIII. JANUARY, 1922. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

This Society is not responsible for any statement made or opinion expressed in its publications.

SOCIETY AFFAIRS

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MINUTES OF MEETINGS

OF THE SOCIETY

January 4th, 1922.—The regular business meeting of the Society was called to order at 8 P. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 87 members and guests.

The minutes of the meetings of November 16th and 17th and December 7th and 8th, 1921, were approved as printed in *Proceedings* for December, 1921.

The Acting Secretary announced the following deaths:

WILLIAM HENRY BOOTH, of London, England, elected Member, July 4th, 1888; died November 12th, 1921.

HARTWELL PRENTICE FARRAR, of Jackson, Tenn., elected Member, November 1st, 1893; died December 16th, 1921.

Paul Maningham Norboe, of Sacramento, Cal., elected Member, November 1st, 1905; died November 15th, 1921.

James Owen, of Orlando, Fla., elected Member, September 15th, 1869; died July, 1921.

Maurice Stiles Parker, of St. Maries, Idaho, elected Member, February 5th, 1890; died June 3d, 1921.

Hiram Phillips, of St. Louis, Mo., elected Associate Member, January 3d, 1894; Member, November 3d, 1897; died December 22d, 1921.

Charles Henry Prior, of Minneapolis, Minn., elected Member, March 1st, 1882; died November 13th, 1921.

James Alexander Seddon, of Portsmouth, Va., elected Member, November 2d, 1898; died October 1st, 1921.

Sebastian Wimmer, of Beatty, Pa., elected Member, March 2d, 1881; died November 30th, 1921.

Franklin Lincoln Gibboney, of Greensboro, N. C., elected Associate Member, October 31st, 1911; died November 20th, 1920.

Joseph Agur Wells, of New York City, elected Affiliate, January 7th, 1896; died December 5th, 1921.

The meeting was devoted to a discussion of "The National Housing Problem." The subject, "Broad Economic Phases", was presented by Lawson Purdy, Secretary and General Director of the Charity Organization Society of New York City; John M. Gries, Chief of the Division of Housing of the U. S. Department of Commerce; John J. Murphy, former Tenement House Commissioner of New York City; and Lawrence Veiller, Secretary of the National Housing Association.

The subject was also discussed by Messrs. D. L. Turner, T. Kennard Thomson, Eugene W. Stern, and B. A. Howes.

Adjourned at 10:33 p. m., to meet at 10 a. m., on January 5th, 1922.

January 5th, 1922.—The meeting was called to order at 10:15 a. m.; President George S. Webster in the chair.

The subject of the meeting was a continuation of the discussion on "The National Housing Problem." The discussion was opened by Charles W. Leavitt, M. Am. Soc. C. E., who spoke on "Property Improvement and Landscaping", illustrating his remarks with lantern slides. In the absence of Joseph C. Wagner, M. Am. Soc. C. E., his paper on "Planning and Zoning" was read by the Acting Secretary. This subject was also discussed by B. Antrim Haldeman, Chief of the Division of City Planning and Municipal Engineering of the Department of Internal Affairs of Pennsylvania, and a written discussion of the subject by Charles M. Reppert, M. Am. Soc. C. E., was presented by the Acting Secretary. This was followed by a discussion on "House Design" by Mr. Andrew J. Thomas.

The subject was also discussed by Messrs. F. W. Look, Nelson P. Lewis, John Ihlder, Henry H. Curran, and Edward S. Rankin.

Adjourned at 12:15 p. m., to meet at 2 p. m.

January 5th, 1922.—The meeting was called to order at 2 P. M.; Director J. S. Langthorn in the chair.

The afternoon session was devoted to a continuation of the discussion on "The National Housing Problem." Under the subject "Utilities," Ernest P. Goodrich, M. Am. Soc. C. E., discussed the question of "Transportation." Mr. Goodrich was followed by H. Malcolm Pirnie, Assoc. M. Am. Soc. C. E., who addressed the meeting on the subject of "Water Supply." W. L. Stevenson, M. Am. Soc. C. E., presented a paper on "Sewage Disposal," and "Lighting" was discussed by Mr. S. G. Hibben, of the Illuminating Engineering Society, who illustrated his remarks with lantern slides.

The subject was discussed generally by Messrs. William H. Ham, B. H. Howes, H. A. C. Hellyer, H. Malcolm Pirnie, and S. G. Hibben.

Adjourned at 4:30 P. M., to meet again at 8:15 P. M.

January 5th, 1922.—The meeting was called to order at 8:15 P. M.; Vice-President Francis Lee Stuart in the chair.

In continuance of the informal discussion on "The National Housing Problem," the subject, "Legislation and Financing", was presented by Messrs. Allan Robinson, President, City and Suburban Homes Company of New York City; Edward M. Bassett, Counsel, Zoning Committee, New York City; William H. Ham, M. Am. Soc. C. E.; and John Ihlder, Manager, Civic Development Department of the U. S. Chamber of Commerce, Washington, D. C.

The subject in general was discussed by Messrs. William H. Ham and T. Kennard Thomson.

Adjourned.

MARSHAL FOCH HONORED BY ENGINEERING SOCIETIES

On December 13th, 1921, Ferdinand Foch, Marshal of France, was made an Honorary Member of the four National American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers. Unanimously, the governing bodies of these great Societies, aggregating 45 000 members, conferred this signal honor, the only one of its kind, in expression of the appreciation of American engineers for the unmatched services of this master of engineering principles.

The presentation of Honorary Membership took place in the Auditorium of the Engineering Societies Building, in New York City, at 3:45 P. M.; J. Vipond Davies, M. Am. Soc. C. E., President of United Engineering Society, in the chair; and present, also, about 1 000 members and guests.

THE CHAIRMAN.—We have assembled at the call of the Presidents of the four Founder Societies for a purpose which is unique in the history of our Societies.

The American Society of Civil Engineers, the President of which is Mr. George S. Webster, and Secretary, Mr. Elbert M. Chandler,

The American Institute of Mining and Metallurgical Engineers, the President of which is Mr. Edwin Ludlow, and Secretary, Mr. F. F. Sharpless,

The American Society of Mechanical Engineers, the President of which is Professor Dexter S. Kimball, and, in whose absence, is to-day represented by Mr. Alford, and Secretary, Mr. Calvin W. Rice,

The American Institute of Electrical Engineers, the President of which is Mr. William McClellan, represented by Mr. Calvert Townley, and Secretary, Mr. F. L. Hutchinson,

have an aggregate membership of 45 000 qualified professional engineers, practicing in every part of the World.

These Societies represent leadership in the Profession of Engineering. Their membership stands for the highest ideals, the best practice, and for constructive effort.

By vote of the Governing Bodies of these Societies, taken severally, there has been conferred on the World's great leader and hero,

FERDINAND FOCH

Marshal of France, and formerly Supreme Commander of the Allied Armies, the dignity of Honorary Membership.

This action is unprecedented in that it has been taken at one and the same time and is to be conferred by one instrument. It is epochal to our Societies in that it constitutes one more bond of strength and union between the several branches of our profession, as represented by our Founder Societies, and by them with our professional brethren in France.

On this, his first visit to the United States, Marshal Foch has been able to honor us with his presence, through the courtesy of his hosts, the American Legion, who have made this ceremony possible.

United Engineering Society, a Board of Trustees of which I have the great honor to be the Presiding Officer, is, as its name implies, an integral part and parcel of the functions and activities of our Founder Societies, holds

title to this building and property, and administers its research department, endowed by Ambrose Swasey, known as Engineering Foundation, directed by Mr. Charles F. Rand, as Chairman, and Mr. Alfred D. Flinn, as Secretary, and also the Library which we claim to be the best equipped technical library of Engineering in existence, with Dr. Harrison W. Craver, as Director.

In this, our home, the General Headquarters of the Profession, it is to-day our honor to receive Marshal Foch.

WILLIAM BARCLAY PARSONS, M. AM. SOC. C. E.—Monsieur le Maréchal: L'art de l'ingénieur a été défini, il y a bien longtemps: "L'art de diriger les grandes sources d'énergie dans la nature pour l'usage et la commodité de l'homme." Nous n'en pourrions trouver aujourd'hui une meilleure définition. De toutes les sources d'énergie la plus grande, la plus précieuse, et en même temps la plus difficile à diriger est l'énergie de l'homme lui-même. Celui qui peut diriger l'énergie humaine et la tourner au service de l'humanité est un grand ingénieur.

Vous, M. le Maréchal, avez dirigé une plus grande masse d'énergie humaine qu'aucun autre avant vous. Et vous l'avez dirigé avec succès vers le plus noble but que l'humanité puisse se proposer, car, avec son aide, vous avez préservé le plus précieux de ses biens, "la liberté," non seulement pour votre glorieuse patrie, mais pour toutes les nations du monde.

Les quatre Sociétés Nationales des Ingénieurs des Etats-Unis désirent reconnaître ce fait et exprimer leur admiration la plus profonde pour le grand chef que vous êtes, en vous nommant membre honoraire de toutes ces sociétés, le plus haut honneur qu'il soit en leur pouvoir de décerner et qui jusqu'à ce jour n'a jamais été conféré à qui que ce soit.

Quatre mille membres de ces sociétés ont été enrolés dans le service armé des Etats-Unis, dont la plupart ont eu le glorieux honneur de servir la cause commune, en France, sous vos ordres. Dans la bataille ils ont entendu la voix du maître et ils ont vu le geste de sa main comme il les conduisait à la victoire.

Nous désirons que vous continuiez à nous guider, dans la paix, en nous permettant d'inscrire votre nom en tête de notre tableau d'honneur où il sera, ce que vos actions ont été pour nous, un exemple à mieux faire, et où il restera à jamais pour les générations futures, une noble inspiration.

M. le Maréchal, au nom des membres des Sociétés qui ont servi sous vos ordres, surtout au nom de ceux qui sont morts en France, au champ d'honneur, je vous salue!

(*Translation*):

Marshal: The art of engineering was defined a long time ago as "The art of directing the great sources of power in Nature for the use and convenience of Man." No better definition can be found to-day. Of all the sources of power in Nature, the greatest, the most valuable, and at the same time the most difficult to direct, is the energy of man himself. He who can direct human energy and turn it to the service of mankind is a great engineer.

You, Marshal, have directed a greater mass of human energy than any other man has ever done. And you have successfully directed this mass for

the highest uses of mankind, in that you by its aid have preserved for him one of the most precious of human possessions—liberty! Liberty not only for your own illustrious country, but for all the nations of the world.

The four National Engineering Societies of the United States now desire to make record of their appreciation of this fact and to convey to you an expression of their most profound admiration for the great leader of men by conferring on you Honorary Membership in all the Societies, the highest honor in their gift and one hitherto never conferred on a single individual.

Four thousand members of these Societies were enrolled in the armed service of the United States, the greater part of whom had the glorious distinction to serve the common cause in France under your orders. They heard the voice and they saw the hand of the master as he led them through battle to victory. Now, we desire that you will still continue to lead us, but in peace, by permitting us to inscribe your name at the head of our roll of honor, where it will be, as your deeds have been, an example to us to do better work, and where it will remain forever a noble inspiration for all future generations.

Marshal, in the name of those members of the Societies who served under your orders and particularly in the name of those who fell on the field of honor in France, I salute you!

Mr. President, Ferdinand Foch, Marshal of France, victorious generalissimo of the allied armies in Europe, stands before you to receive honorary membership in the four National Engineering Societies of the United States.

George S. Webster, President, Am. Soc. C. E.—Ferdinand Foch, Marshal of France, Commander in Chief of the victorious armies of the Allies, master of military strategy, foremost military engineer, the hope of the civilized world during the dark days of the War, idol of the exponents of liberty and justice, military genius whose effective co-ordination of the armies of the Allies and whose indomitable will inspired them with the hope and the renewed vigor which brought the World War to a successful close!

In recognition of these achievements and of your unparalleled service to Mankind, I have the honor on behalf of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, to present to you this Certificate of Honorary Membership, signed by the President and Secretary of each Society, and also these emblems of membership in the Societies.

Le Maréchal Foch.—Monsieur le Président—Messieurs: Que sont les nations, sans l'ingénieur civil? Que serait aujourd'hui notre civilisation, et que deviendrait notre activité dans la paix? Pas grand'chose. Nous existerions, sans doute, a l'état de peuples plus ou moins barbares. Mais, quand il s'agit de la guerre, le génie est encore aujourd'hui tout aussi nécessaire, aussi indispensable, qu'auparavant. Oui. Que deviendrait notre science militaire sans l'aide technique, sans le savoir professionnel, sans la connaissance que vous avez contribués de toute façon? Comment aurions-nous pu transporter nos armées, les alimenter, les faire arriver sur le champ de bataille, et puis, sur le champ de bataille, les abriter, les protéger? C'est grâce à vous—

aux efforts que vous avez portés—que nous avons pu permettre aux armées d'avancer vite et gagner la victoire. Et c'est pour ça qu'aujourd'hui, en venant vous trouver ici, je viens vous témoigner cette reconnaissance qui vous est due, et pour vous dire hautement:—Merci! (Applaudissements.) Oui, c'est pour ça aussi que je suis particulièrement fier du fait que vous voulez bien me compter dans vos rangs, en raison des services que vous avez rendus, et que j'apprécie si hautement. La guerre n'aurait pas été possible sans vous, sans votre co-opération et votre science. Messieurs, votre aide nous est indespensable dans l'avenir, comme dans le passé, et nous comptons sur vous pour repondre aux demandes de la patrie quand ils s'imposeront. (Vifs applaudissements.)

(*Translation*):

Mr. President—Gentlemen: What are the nations without the civil engineer? What would be to-day our civilization, and what would our activity amount to in times of peace? To very little indeed. We would undoubtedly live in the condition of more or less wild peoples. But when it comes to war, engineering is even to this day as necessary and as indispensable as in the past. Yes, what would our military science amount to without technical assistance, without professional knowledge, without your skilled contribution. How would it have been possible for us to transport our armies, to feed them, to bring them to the battle field, to shelter them, to protect them? It is you and your endeavors that have made it possible for us to bring forward quickly our armies, and to secure the victory. This is the reason why in calling upon you to-day I feel it to be my duty to acknowledge your services, and to tell you aloud: Thank you! (Applause). This is one of the reasons why I feel extremely proud of the fact that you have appointed me to be one of you, as I am fully alive to the services you have rendered, which services I greatly appreciate. The war would have been impossible without you, without your co-operation, without your science. Gentlemen, your help will be indispensable for us in the future as it has been in the past, and we rely upon your prompt answer to the calls of the country should a necessity arise. (Hearty applause).

MINUTES OF MEETINGS OF SPECIAL COMMITTEES TO REPORT ON ENGINEERING SUBJECTS

Special Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, Etc.

November 22d, 1921.—The meeting was called to order at 3 P. M., at the Headquarters of the Society. Present, Robert A. Cummings (Chairman), Allen Hazen, J. C. Meem, A. T. Goldbeck (by invitation), and E. G. Haines (Secretary, *pro tem.*).

The minutes of the previous meeting were read and approved.

The budget for 1922 and correspondence between the Committee and the Acting Secretary in regard to the matter of appropriation, were read.

A. T. Goldbeck, Assoc. M. Am. Soc. C. S., was introduced and explained in detail the work of the United States Bureau of Public Roads in regard to the testing of soils. At the request of the Committee, Mr. Goldbeck agreed to submit, as a sub-committee report, a statement on the activities of the Bureau of Roads.

The budget appropriation for 1922 was discussed, and on motion, duly seconded, the Chairman was instructed to request the sum of $2 500. The Chairman also reported on various expenses chargeable to the Committee's budget of 1921.

The report of E. E. Halmos, M. Am. Soc. C. E., on the question of submitting to the Society a new formula for soil pressure, was presented to the Committee. On motion, duly seconded, it was decided that Mr. Halmos' report should be edited and incorporated as a sub-committee report. It was announced that the design and building of a large scale soil-testing apparatus for the determination of the distribution of pressure in bins and footings was under consideration by the Committee.

It was reported that a bibliography of the published literature of Colloids in Clays was being prepared, and on motion, duly seconded, it was decided that this bibliography should be submitted to members of the Committee in order to decide whether or not it should be included as an Appendix to the report for 1921.

The Secretary reported on the Questionnaire sent out by the Committee on August 3d, 1921, relative to the settlement of soils under tests and loads, and stated that the machine recommended by the Committee in 1919 had been used with satisfactory results. On motion, duly seconded, it was decided that the results of the Questionnaire and of the use of the Committee's recommended machine be prepared as a sub-committee report for 1921.

A report of the work conducted by Professor J. H. Griffith, M. Am. Soc. C. E., at Iowa State College, was presented, and on motion, duly seconded, this report was ordered to be included as a sub-committee report for 1921.

The Chairman reported that John F. Coleman, M. Am. Soc. C. E., and H. M. Gallagher, Assoc. M. Am. Soc. C. E., were preparing to make pressure tests with Goldbeck gauges on the lock walls at New Orleans, La., and also lateral pressure tests.

On motion, duly seconded, the meeting was adjourned subject to the call of the Chair.

Special Committee on Specification for Bridge Design and Construction

December 2d, 1921.—The meeting was called to order at the Headquarters of the Society. Present, Henry B. Seaman (Chairman), B. R. Leffler, M. S. Ketchum, C. W. Hudson, and Howard C. Baird (Secretary).

The resignation of Mr. George H. Pegram as a member of the Committee was received and accepted with great regret.

The presentation of the Steel Railway Bridge Specification* was discussed informally, with special reference to the desirability of individual discussion to be printed in *Proceedings* with the Specification.

The subject of Live Loads for Highway Bridges was discussed. On motion, duly seconded, it was decided to hold the next meeting of the Committee at the University of Pennsylvania, on February 10th and 11th, 1922, the session of February 10th to be held jointly with the Committee on Highway Bridges of the State Highway Officials.

The morning session was devoted chiefly to the discussion of Live Loads and Impact on Highway Bridges, and the afternoon session to a discussion of the Distribution of Concentrated Loads on Slabs and Stringers of Concrete Structures.

December 3d, 1921.—The meeting was called to order at the Headquarters of the Society with the same attendance as at the previous meeting.

This session was devoted to a continuation of the discussion of Distribution of Loads on Slabs. This was followed by a discussion of the proposed limitation of span lengths for various types of concrete structures and specifications for details of construction.

On motion, duly seconded, the Committee adjourned at 4.30 P. M. to meet on February 10th, 1922, at the University of Pennsylvania, Philadelphia, Pa.

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 683.

ITEMS OF INTEREST

The Committee on Publications will be glad to receive communications of general interest to the Society, and will consider them for publication in *Proceedings* in "Items of Interest". This is intended to cover letters or suggestions from our membership concerning matters which are not of a technical character. Such communications, however, must not be controversial or commercial.

THE ENGINEERING FOUNDATION

The Engineering Foundation was established in 1914 "for the furtherance of research in science and engineering, or for the advancement in any other manner of the Profession of Engineering and the good of mankind", and for the following purposes: To promote and support worthy researches related to engineering in all its branches; to establish and operate engineering research laboratories, if funds be provided therefor; to co-operate with National Research Council and the Engineering Societies in the stimulation and co-ordination of scientific research.

Endowment Funds Needed.

The Foundation needs a large increase of endowment. It is obliged frequently to refuse to support research projects brought to it because it lacks funds. Gifts of $1 000 or more are desired. Each donor of $250 000 or more will be honored as a Founder. A gift of $50 000 has been offered contingent on the receipt of nine other gifts of $50 000 each. Gifts to the Foundation are exempt from income tax. A gift for research is a productive investment.

The Foundation is compiling a directory of the hydraulic laboratories of the United States, and is planning an investigation of industrial education and training. It undertakes useful researches which do not promise profits sufficient to tempt industrial organizations to undertake them, researches which should be made under disinterested auspices, and researches which lie outside the province of Government bureaus.

The Engineering Foundation is administered under the auspices of the United Engineering Society, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, by a board of thirteen representatives of these Societies, and three members at large.

A progress report of the Foundation, a form of Deed of Gift, and other information will be sent by the Secretary, Alfred D. Flinn, M. Am. Soc. C. E., 29 West 39th Street, New York City, on request.

Joint Conference of Engineers, Architects, and Constructors, Held in Washington, D. C., December 15th and 16th, 1921, Plans to Standardize Construction Contracts

This Conference was composed of delegates appointed by eight National societies, representing the engineers, architects, and contractors of the United States, and the definite plan adopted was one which would ultimately produce a standard form of contract "agreement" which would be acceptable in all sections of the United States and in all phases of this huge industry.

A survey of the situation made several months ago by Gen. R. C. Marshall, Jr., M. Am. Soc. C. E., disclosed the fact that to-day there are in common use throughout the construction industry, more than 200 different forms of contracts, and that no one State or section had yet been able to establish any one form as standard or customary.

Engineers at the Headquarters of the Associated General Contractors of America in Washington, were then assigned the task of analyzing these 200 different forms, in order to discover whether the variety of "jobs" involved required any such variety of forms.

W. P. Christie, Assoc. M. Am. Soc. C. E., in charge of this work as Research Engineer for the Associated General Contractors, reported that the differences were chiefly superficial and that at least two-thirds of all the provisions contained in each of the 200 documents were common to all documents, and, therefore, could be included in one standard contract form, if rewritten in simple universal style.

It was found that stipulations which were characteristic or peculiar to the building trades, to railroad construction, to water-work projects, or to highways could be assembled in one standard form, entitled "General Conditions", applicable to that one field of construction only, and added to the standard agreement form as addenda.

In this manner, it would be quite possible to draft a standard contract which would cover all cases of construction work, no matter in what field, and the only alteration that it would ever need, would be in selecting the standard form of "General Conditions" which covered the type of job concerned. Experts believed that a half dozen such forms would cover the main subdivisions involved in the construction industry.

This plan, together with a "tentative outline", was submitted for consideration to the: American Society of Civil Engineers, American Association of State Highway Officials, American Engineering Council, American Institute of Architects, American Railway Engineering Association, American Waterworks Association, Associated General Contractors of America, National Association of Builders Exchanges, and Western Society of Engineers.

All these organizations responded favorably and appointed representatives to come to Washington to constitute a conference on the subject and proceed with the drafting of a tentative form of contract which, later, could be officially submitted by the Conference to its constituting bodies for criticism, amendments, and ultimate ratification.

The Conference met in the Assembly Room of the Department of Commerce Building, in Washington, on December 15th and 16th, 1921, and was

addressed by Secretary of Commerce Hoover and Gen. Marshall, both of whom expressed a lively and sincere hope that the Conference would ultimately devise a form which would become as standard in its field as the standard forms of bank checks, notes, and mortgages are in the field of banking and commercial trade.

The aim of the Conference in beginning work on this difficult task was to achieve the following advantages for the entire construction industry and all its affiliations: (1) Less expenditure and legal service; (2) less duplication of work in the professions; (3) elimination of disputes; (4) better safeguard for owners and increased public confidence; and (5) an improved standard of construction service throughout the country.

The officers of the Conference were elected, as follows: Chairman, Onward Bates, Past-President, Am. Soc. C. E., of Chicago, Ill., representative of the Western Society of Engineers; Vice-Chairman, J. W. Cowper, Assoc. M. Am. Soc. C. E., of Buffalo, N. Y., representative of the Associated General Contractors, who served as Chairman during the first session owing to the illness of Mr. Bates; and Secretary, W. P. Christie of Washington, D. C.

Gen. Marshall and Mr. William B. King representing, respectively, the Associated General Contractors and the American Bar Association, were elected members of the Conference. Other delegates were: W. A. Rogers, M. Am. Soc. C. E., of Chicago, Ill., substitute delegate for the Western Society of Engineers; E. W. Reaugh, of Cleveland, Ohio, for the National Association of Builders' Exchanges; A. P. Davis, Past-President, Am. Soc. C. E., for American Engineering Council, substituted for by L. W. Wallace; J. Waldo Smith, M. Am. Soc. C. E., of New York City, for the American Waterworks Association; William S. Parker, of Boston, Mass., for the American Institute of Architects; H. K. Bishop, M. Am. Soc. C. E., of Washington, D. C., for the American Association of State Highway Officials; H. Eltinge Breed, M. Am. Soc. C. E., for the American Society of Civil Engineers, substituted for by J. S. Langthorn, M. Am. Soc. C. E.; and W. D. Faucette, M. Am. Soc. C. E., for the American Railway Engineering Association.

The final session of the Conference was devoted to a detailed study of clauses which could be approved for incorporation in the standard contract "agreement", the members voting on each topic separately, until a definite list of topics had been made, which seemed acceptable for universal use. It was the consensus of opinion that such a universal document could be achieved, and its scope or length would have to be determined after prolonged consideration of each topic in detail.

It was also decided that, later, sub-committees should be appointed in each phase of the industry to draw up the standard form of "general conditions" (one for the railroads, one for the builders, etc.), which would complement the general "agreement" according to the job.

Thus, the general principles of the universal contract were fixed, and a committee consisting of Gen. Marshall for the constructors, Mr. Parker, for the architects, and Mr. Faucette for the railway engineers, was appointed to write out the document in tentative form for correction and approval by the Conference at its next meeting in January, 1922, after which the forms

will be transmitted officially to the various societies and organizations interested, for further consideration and ultimate adoption.

Before its adjournment, the Conference passed a resolution of appreciation and thanks to Gen. Marshall for the great amount of work he had done in preparing the "tentative outline" and for his untiring efforts in arranging for conference action.

Activities of Engineering Societies Employment Bureau

In an endeavor to improve the present unemployment conditions affecting engineers, a voluntary committee was formed, in November, 1921, of unemployed members residing in the Metropolitan District. The objects were to uncover positions, to locate prospective positions in the near future, and to acquaint all employers with the facilities provided free of charge to both parties, by the Federated American Engineering Societies, for securing the services of engineers specially qualified to handle their problems.

Profiting by the experience of the original Committee, which functioned during the summer, the Committee is working through the medium of personal calls, as it was found that letter-writing and circularizing are not so effective.

The original Committee made 2 300 calls, secured 1 800 interviews, but found that 47% of the prospects did not know of the services provided by the Bureau. It also secured publicity in more than fifty technical and daily papers, thus arousing considerable interest and doing splendid work in advancing the cause of the Engineering Profession. Although the number of positions secured was not great, it should be borne in mind that this work was carried on during the period of greatest depression, and the efforts made will be of greater benefit to the Bureau as conditions improve.

The present Committee is branching out into still broader activities not only by making repeat calls of the most likely of the original prospects, but also by calling on firms not hitherto interviewed, and endeavoring to create a demand for engineering services in lines not ordinarily using engineers.

The work presents such splendid possibilities, and is of such importance and value, that the enterprise should not be confined merely to the Metropolitan District, but should be carried on with equal initiative throughout the United States. During the Annual Meeting of the American Society of Mechanical Engineers a number of Sectional Delegates were approached on the subject, and not only became much interested, but expressed their intention of appointing similar committees, in their Local Districts. Committees are now under way in Philadelphia, Pa.; Cleveland, Ohio; New Haven, Conn.; Richmond, Va.; and Boston, Mass., and the Employment Service is anxious to encourage and co-operate in this work.

Full information as to details may be obtained by writing to W. V. Brown, Manager, Employment Service, Federated American Engineering Societies, 29 West 39th Street, New York City.

ACTIVITIES OF LOCAL SECTIONS*

Regular Meeting of Buffalo Section

A meeting of the Buffalo Section was called to order on December 13th, 1921, at the club rooms of the Engineering Society of Buffalo, Iroquois Hotel; President A. L. Johnson in the chair; Bruce L. Cushing, Secretary; and present, also, 35 members and guests.

Following the usual luncheon, a paper by John Lyell Harper, M. Am. Soc. C. E., on "The Future of the Niagara Frontier in Regard to the Possible and Probable Development of Power", was presented by the author.

Mr. Harper and Harry J. March, M. Am. Soc. C. E., were elected members of the Section.

Annual Meeting of Detroit Section

The Annual Meeting of the Detroit Section was held at the Fellowcraft Athletic Club, on November 16th, 1921; President David A. Molitor in the chair; Dalton R. Wells, Secretary; and present, also, 23 members and guests.

The business and social session was preceded by an informal dinner.

The following officers were elected for the ensuing year: President, H. H. Esselstyn; First Vice-President, E. M. Walker; Second Vice-President, Dalton R. Wells; Secretary-Treasurer, Alex. Linn Trout.

The principal speakers of the evening included Capt. Joseph S. Stringham, Col. Esselstyn, President Molitor, and Gardner S. Williams. In their addresses, Capt. Stringham and President Molitor described personal experiences in South America in connection with Governmental engineering work.

After his election as President, Col. Esselstyn addressed the meeting, outlining constructive plans for the benefit of the Section.

Minutes of Meeting of Cleveland Section

A meeting of the Cleveland Section was called to order on December 14th, 1921, at the Winton Hotel; Vice-President A. V. Ruggles in the chair; George H. Tinker, Secretary; and present, also, 15 members.

The minutes of the meeting of November 9th, 1921, were read and approved.

The Secretary read copies of letters sent to Mayor-elect Fred Kohler and the Cleveland Engineering Society recommending the appointment of an engineer as Director of Public Service.

The Chairman appointed Messrs. K. H. Osborn, D. W. Morrow, and A. G. Levy, as a Nominating Committee to select the names of officers for the coming year.

Mr. W. J. Carter presented a preliminary report from the River and Harbor Committee, which he illustrated by a large map showing the recommended straightening of the Cuyahoga River and the suggested change of alignment of the proposed Lorain-Huron Bridge. The report was discussed by Messrs. Thomas, Pease, Bissell, Brown, Carter, Tinker, and others.

On motion, duly seconded, the report and map were accepted by the Section and copies were ordered sent to the Chamber of Commerce, the Chamber

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* For list of Local Sections, Officers, etc., see p. 24.

of Industry, the City Council, County Commissioners, Congressman Theodore Burton, and Mr. T. J. Ray.

The Nominating Committee presented the following names for officers for 1922: President, A. V. Ruggles; Vice-President, F. E. Bissell; and Secretary-Treasurer, George H. Tinker. On motion, duly seconded, the nominations were closed, and these officers were declared elected.

Annual Meeting of District of Columbia Section

The Annual Meeting of the District of Columbia Section was held at the Cosmos Club, Washington, D. C., on December 14th, 1921; President John C. Hoyt in the chair; James H. Van Wagenen, Secretary; and present, also, 43 members.

The following officers were elected for the ensuing year: President, Gratz B. Strickler; Vice-President, W. E. Parker; and Secretary-Treasurer, James H. Van Wagenen.

The speaker of the evening, Mr. N. C. Grover, Chief Hydraulic Engineer of the U. S. Geological Survey, addressed the meeting on his impressions of Haiti where he had recently spent two months in making a reconnaissance survey of the water resources.

Illinois Section Elects Officers

The Annual Meeting of the Illinois Section was held in Chicago, Ill., on December 21st, 1921.

No special business was transacted, except the election of officers for the ensuing year, as follows: President, A. J. Hammond; Vice-President (one year), James N. Hatch; Vice-President (two years), T. L. Condron; and Secretary-Treasurer, W. D. Gerber.

Annual Meeting of Kansas City Section

The Annual Meeting of the Kansas City Section was held at the University Club on December 6th, 1921; Vice-President John V. Hanna in the chair; Henry C. Tammen, Secretary; and present, also, 22 members.

A report was presented from the Committee appointed to act with the Engineers Club of Kansas City in the matter of recommendation of engineers qualified to serve as members of the Missouri Highway Commission. On motion, duly seconded, this report was approved.

The Secretary presented his report for the year, which showed a present membership of 82. On motion, duly seconded, this report was approved.

At the request of the Chairman of the Committee on Licensing Engineers of the Society, the meeting considered the question of licensing, and after a discussion of the subject, the following resolution was adopted:

"*Resolved:* That the Kansas City Section wishes to express itself as being in favor of licensing engineers and recommends to the Committee on Licensing of Engineers that efforts be made to secure uniformity with provisions for reciprocity in the license laws of the various States."

The following officers were elected for the ensuing year: President, John V. Hanna; Vice-President (2-year term), E. M. Stayton; Vice-President (1-year term), Wynkoop Kiersted; and Secretary-Treasurer, Henry C. Tammen.

An informal paper, dealing with "The Railway Terminal Problems of Kansas City," was presented by Vice-President Hanna.

The paper was followed by a discussion of the proposed location of the intake for the future water supply of Kansas City by Messrs. Hanna, McClintock, Howard, and Treadway.

Annual Meeting of Los Angeles Section

The Annual Meeting of the Los Angeles Section was held at the Wilshire Country Club, on December 14th, 1921; Past-President George G. Anderson in the chair, F. G. Dessery, Secretary; and present, also, 27 members and 11 guests.

The Chairman introduced as the guests of the Section, Mr. R. C. Jeffrey, Assistant to the Chief Engineer of the Ontario Power Commission, who gave a short illustrated talk on "Power Development in Canada at Niagara Falls"; Arthur P. Davis, Past-President, Am. Soc. C. E., who gave an interesting talk on the activities of the Society and of other Local Sections; A. J. McCune, State Engineer of Colorado, who spoke on "Activities of Engineers"; and Messrs. William Davidson, R. E. Shonerd, M. D. Pratt, and F. W. Blackford.

Mr. S. A. Jubb, of the Committee on Building Laws and Regulations, opened the discussion on the report of that Committee, and a written discussion from Mr. R. P. Miller on the subject was read by the Secretary. The report was discussed by Messrs. Wheeler, Adams, Jubb, Morris, Halsey, Flaherty, Leeds, and Dennis, and on motion, duly seconded, the Majority Report of the Committee was adopted.

The action of Governor Stephens and Austin B. Fletcher of the State Board of Control, in removing from office Mr. Charles H. Lee, was briefly outlined by the Chairman, and correspondence and telegrams between the Secretary, the Governor, and others were read. On motion, duly seconded, the action of the President and the Secretary of the Section in sending these telegrams was approved.

Reports were presented by the Committees on Public Health and Sanitation, Co-operation with Federal Bureaus, Standard Specifications for Concrete Pipe, Public Library, Substructures in Coastal Waters, Building Laws and Regulations, Conservation, and Sewerage.

In the absence of Treasurer E. R. Bowen, Mr. J. G. Heft presented the report of the Treasurer, which, on motion, duly seconded, was unanimously adopted. The expenditures of the Secretary and Treasurer during the year were approved, and Treasurer Bowen was extended a vote of thanks for his work.

The report of the Secretary, covering the work of the Section, was presented, and in commenting on this report, Chairman Anderson stated that he believed that the activities of the Los Angeles Section were not exceeded by any other Section of the Society. Past-President Davis also congratulated the Section and President Dennis on the work of the Section.

On motion, duly seconded, a unanimous vote of thanks was given Secretary Dessery for his work during the year, and the Board of Directors was authorized to relieve the Secretary of any personal expense incurred by him in the performance of his duties.

The election of the following officers for 1922 was announced: President, R. J. Reed; Vice-Presidents, F. D. Howell and W. H. Code; Secretary, F. G. Dessery; and Treasurer, E. R. Bowen.

Chairman Anderson presented a communication from President-elect Ralph J. Reed, and a rising vote of thanks was extended to retiring President Dennis. In conclusion, Chairman Anderson called on those present to take an active interest in Society affairs and to build up the membership of the Local Section.

New York Section Discusses Effects of Zoning Law

The first regular meeting of the New York Section was held on December 21st, 1921, the meetings for October and November having been joint meetings with the other Local Sections of the Founder Societies; President Nelson P. Lewis in the chair; J. P. J. Williams, Secretary; and present, also, about 127 members and guests.

The minutes of the Annual Meeting held May 18th, 1921, were approved.

Mr. E. J. Mehren, Chairman of the Program Committee, announced tentative proposals for sub-sections in the various technical fields and the holding of group meetings for informal discussion of live problems. He requested those present to fill out and return questionnaire blanks distributed for the purpose of learning how many would actively support such additional group meetings.

The Secretary announced that the Tellers appointed at the Annual Meeting to canvass the ballots on Amendments to the Constitution reported that more than the necessary votes had been obtained in the affirmative, and that the Board of Directors had declared the revised Constitution and By-Laws adopted, the Amendments having been approved by the Board of Direction of the Parent Society.

The topic of the evening, "The Zoning Law—What It Has Done for New York," was presented by Mr. Edward M. Bassett, former Rapid Transit Commissioner and Chairman of the Special Commission which framed the Zoning Ordinance, and Mr. Lawson Purdy, former Commissioner of Taxes and Assessments of New York City. The subject was discussed by Messrs. Rudolph P. Miller, Superintendent of Buildings, Borough of Manhattan (by letter); John P. Fox, Secretary of the Murray Hill Association; Clarence S. Stein, Architect; H. H. Curran, President of the Borough of Manhattan; Amos Schaeffer, E. W. Look, D. L. Turner, and T. Kennard Thomson.

The principal advantages gained through the six years' operation of the New York zoning ordinance, according to Mr. Bassett, are that it has checked the infiltration of hurtful industries into residence and high-class retail store districts. Except in compliance with special conditions, public garages and service stations have also been kept out of residential zones. He cited the Fifth Avenue District particularly as having been threatened by the invasion of garment makers, and saved by the aid of the "Save New York" movement.

He spoke of the new type of high building with set-back outlines developing distinctive architectural effects, and of the importance of the great degree of security guaranteed to the home owner in protected residence zones. The power to enforce such restrictions as to height, use, and area of lot covered by building was obtained, he said, through an amendment to the City Charter under the police power of the State. This ground he felt to be much more secure than the right of eminent domain, and it has been supported by Court rulings "for the health, safety, morals, and general welfare of the community."

Mr. Bassett concluded by referring to the great aid to the City Engineer afforded by zoning restrictions which allow layouts of streets and blocks to conform to known developments and uses, and cited the case of one city where $200 000 had been saved in street structure and utilities through the zoning plans.

Mr. Purdy emphasized the need for considering New York City as one whole, not merely as the Island of Manhattan, and said that Brooklyn would soon have a population exceeding that of Manhattan, the latter containing but 21 sq. miles of the 329 composing Greater New York. He spoke of the losses in value of property along 23d Street due to business changes, and said that such losses should not happen again. One result of zoning which pleased him particularly was the exclusion from residence districts of all advertising signs. He suggested several improvements which should be made in the present law, such as making height restrictions more severe in residence districts, and adding a 45% area zone intermediate between the present 30% and 60% area limitations.

Mr. Miller pointed out that the New York Zoning Law had started a great zoning movement throughout the country, its most important aspect being the limitations as to use and area of lot covered. The greatest difficulty of enforcement, he claimed, was the encroachment into new or old buildings of uses not conforming to the district—such as architects' offices, seamstresses, etc. One important feature of the law he felt to be particularly valuable, namely, the requirement that a new building, or one in which alterations are made, cannot be occupied until a certificate of occupancy has been secured, fixing definitely the uses to which the building may be put. Permits for more than forty high buildings have been issued under the set-back requirements, although but few of them are constructed, yet those few in some cases show the most pleasing architectural effects.

Mr. Fox outlined in detail the difficulties in enforcing the residence district requirements in the Murray Hill Section, and stated that the Board of Estimate had strongly supported the ordinance by not granting appeals to admit business into the district. The weakness of the law, he said, is its lack of effective and quick enforcement penalties.

Mr. Stein stated that as an architect he was most interested in zoning from the standpoint of city planning, viewing the city as a functioning organism. Houses should be provided for easy access to industry, which would mean decentralization of industry. He suggested that a new classification might be made to include the mixed district, with business uses on lower floors and residential use above.

Mr. Curran emphasized the importance of proper transit facilities, comparing the present inadequate conditions to a wheel with hub and spokes, but no rim. He urged development of a cobweb system, with many local industrial centers, each with its own schools, parks, recreation centers, and homes.

Annual Meeting of Pittsburgh Section

The Annual Meeting of the Pittsburgh Section was called to order at the Hotel Chatham, on November 28th, 1921, at 7 P. M.; Vice-President J. N. Chester in the chair; Nathan Schein, Secretary; and present, also, 26 members.

The minutes of the previous meeting were read and approved.

The report of the delegates to the Engineering Council of the Federated Engineering Societies of Pittsburgh, with reference to their action on the report of the Citizens' Committee on City Plan of Pittsburgh, was read and discussed. On motion, duly seconded, it was resolved "That this Section endorses the action of the Engineering Council in introducing in general the report of the Citizens' Committee on City Plan."

After a discussion of the various Planning Commissions in Pittsburgh, it was moved, seconded, and carried, that the members of the Section and the Engineering Council be instructed to bring before the Council of the Federated Engineering Societies of Pittsburgh the necessity of a County Planning Commission with adequate legal authority in like capacity to the present City Planning Commission.

A letter was presented from the Library Committee of the Pittsburgh Section of the American Chemical Society relative to the appropriation of the City Council to the Carnegie Library, and on motion, duly seconded, the action of this Committee was endorsed, and the Secretary was instructed to forward the letter to the Pittsburgh Council, urging adequate appropriation for books.

The following officers were elected for the ensuing year: President, J. N. Chester; Vice-President, J. L. de Vou; and Secretary-Treasurer, Nathan Schein.

The new President, Mr. Chester, addressed the meeting, thanking the members for the honor bestowed on him, after which he announced that the subject at the next meeting of the Section would be a discussion regarding the possibility of presenting engineering papers before the Section.

Annual Meeting of St. Louis Section

The 107th meeting of the St. Louis Section was called to order at the University Club, on November 28th, 1921, at 7 P. M.; President William S. Mitchell in the chair; W. R. Crecelius, Secretary; and present, also, 14 members.

The minutes of the meeting of October 24th, 1921, were read and approved.

The Secretary presented a letter from the Washington University Collimation Club Student Chapter requesting speakers for the meetings of the Chapter, and on motion, duly seconded, the President was instructed to appoint such speakers to address the Chapter at its convenience. The members of the Chapter were also invited to attend the next meeting of the Associated Societies held under the auspices of the Section.

Reports were made by the Secretary-Treasurer and the Chairmen of the Standing Committees.

Mr. C. D. Purdon, Chairman of the Committee on Revising the Constitution and By-Laws, reported a tentative draft of a new Constitution. On motion, duly seconded, the report was accepted and the Committee continued.

Mr. A. P. Greensfelder, Chairman of the Civics Committee, reported on the activities of the Committee during the past year and recommended that reports on the investigation of bond issues, revision of the City Building Code, Quantity Surveying, and the new Constitution of the State of Missouri be prepared during the coming year.

New officers of the Section were elected as follows: President, E. B. Fay; Vice-President, A. O. Cunningham; Secretary-Treasurer, William C. E. Becker; and Member to the Joint Council of the Associated Engineering Societies of St. Louis, C. D. Purdon.

The subject for discussion at the meeting was "Should Engineers in Public Service and Semi-Public Service Be Employed Under Civil Service Rules or Should Rotation in Office Be the Rule"? The subject was discussed by Messrs. Greensfelder, Atwood, Mitchell, Allison, Purdon, Russell, Ockerson, and Crecelius, but no definite decision as to the merits of the methods of employment was reached.

EMPLOYMENT SERVICE OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

An Engineering Societies Service Bureau was established December 1st, 1918, as an activity of Engineering Council, managed by a board made up of the Secretaries of the four Founder Societies, funds for its maintenance being provided by these Societies. On January 1st, 1921, this Bureau was taken over by The Federated American Engineering Societies and is now known as the Employment Service of that organization. It is co-operating with engineering organizations in all parts of the country and is desirous of increasing such co-operation by working with local engineering associations and clubs. Members of the American Society of Civil Engineers who desire to register should apply for further information, registration forms, etc., to Walter V. Brown, Manager, Engineering Societies Building, 29 West 39th Street, New York City. In order to be included in the list published in *Proceedings,* copy must be received on or before the first Wednesday of each month. All communications should be addressed to Mr. Brown.

EMPLOYMENT BULLETIN

MEN AVAILABLE

ENGINEER, M. Am. Soc. C. E. and A. I. M. E., with New York City office, desires to act as engineering, purchasing, or sales representative whole or part time, fee or commission basis. CE–290.

ENGINEERING REPRESENTATIVE OR SALES ENGINEER, Assoc. M. Am. Soc. C. E., age 39. Seventeen years' experience in all branches of engineering and construction, especially railway, highway, hydro-electric, and harbor work. Served as Captain, Engineers, U. S. A., in France, where work was engineering supply and motor-transport operation. Since then has specialized in motor-transport operation and cost and in automobile, motor-truck, and machinery sales. Now located in Pacific Northwest. Prefers this location, but would accept Oriental or other foreign commission. Salary commensurate with duties. CE–291.

GRADUATE CIVIL ENGINEER AND CONSTRUCTION SUPERINTENDENT, degree 1908, Assoc. M. Am. Soc. C. E., age 34. Twelve years' experience, roads, bridges, surveys, sewers, water-works, and concrete industrial buildings. Experience includes design, inspection, and superintendence. Two years in charge of war work for Construction Division, U. S. A. Available at once. Location immaterial. CE–292.

SALES ENGINEER. Fifteen years' experience in engineering, organization, executive, and sales. Good knowledge of business and selling principles. Salary and commission. CE–293.

ENGINEER. Ten years' experience in all kinds of field work, city, street, land, irrigation, railroad, and river. Experience in operation and maintenance of water supply and sewage disposal systems; also as Construction Foreman and Superintendent on concrete foundations and earthwork. More than three years as Engineer Officer in U. S. Army, about half of time detailed to Construction Division. Prefers work of permanent character, such as operation of utilities. CE–294.

CIVIL-MECHANICAL SUPERVISING ENGINEER, Assoc. M. Am. Soc. C. E., age 35. Well varied experience in power, hydraulic, and industrial work, both engineering and construction. Record of responsible and executive connections with well-known organizations; thorough business training. Experience throughout the country; now in Chicago district. CE–295.

CIVIL ENGINEER, Assoc. Am. Soc. C. E., 33, married, with thirteen years' field and office experience in construction of tunnels, subways, steam and hydro-electric power plants, desires position as Resident Engineer. CE–296.

MINING AND MECHANICAL EXECUTIVE, University Instructor, or Editorial Engagement. Age 44, married. Technical (Lehigh University) graduate. Twenty-two years' practical experience in engineering, managerial, vocational instructor, and editorial work with large corporations. North or West preferred. CE-297.

GRADUATE ENGINEER, Assoc. M. Am. Soc. C. E., age 39, married. Sixteen years' experience along construction lines, including design and erection of large reinforced concrete and steel structures; has also had experience in water supply engineering, streets and pavements, and dredging. Would prefer position as Engineer of Building and Maintenance with industrial concern or with general contractor. CE–298.

ANNOUNCEMENTS

The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

CATALOG OF ENGINEERING SOCIETIES LIBRARY

The first installment of the catalog of Engineering Societies Library, which has been in process of recataloging for the last three years, may be found on page 55.

The special attention of members of the Society interested in Highway Engineering is called to this list.

LIBRARY BOOK LOANS

The Library Board of the Engineering Societies Library has adopted rules authorizing the Director of the Library to lend to members of any Founder Society any duplicate books in the Library, subject to the following rules:

1.—Duplicate books may be lent to members of Founder Societies or of any other societies that contribute to maintain the Library.

2.—Books will be lent for twenty-eight days, including time in transit.

3.—Five cents a day will be charged for each book kept longer than twenty-eight days.

4.—Borrowers shall be responsible for books borrowed, and shall pay shipping and insurance charges from and to the Library.

The Library has several thousand volumes that can be lent under this authorization. These include a considerable number of textbooks, reports, etc., of various dates. Periodicals are not included, as the cost of storing duplicate sets seems prohibitive and individual articles can be photoprinted at little expense. The collection is being increased regularly by the addition of any suitable duplicates received by the Library. Members are invited to present any books of permanent value for this purpose, which they can spare from their libraries. It is hoped that in time the collection may become adequate to meet the usual needs of members by providing any standard book required for a short time.

No catalog has been published, although it is hoped that one may be, when the collection becomes extensive enough to warrant doing so. Until that time, the Director will be glad to receive requests and report whether the books are available or not.

SEARCHES IN THE LIBRARY

As the Library of the American Society of Civil Engineers has been merged in the Engineering Societies Library, requests for searches, copies, translations, etc., should be addressed to the Director, Engineering Societies Library, 29

West 39th Street, New York City, who will gladly give information concerning the charges for the various kinds of service. A more comprehensive statement in regard to this matter will be found on page 21 of the Year Book for 1921.

SECOND MEETINGS OF THE MONTH

Under authority given by the Board of Direction at its meeting of August 9th, 1920, the Acting Secretary has made an arrangement with the New York Section whereby the latter will take over the second meeting of the month, and will thus hold its own meetings on the third Wednesday of each month, except January and May, when they are held on the second Wednesday.

The programmes of the New York Section* are similar to those heretofore offered by the Society's Committee on Second Meeting of the Month, and it is understood that all members of the Society are invited to attend the meetings regardless of whether or not they may be members of the Section. This arrangement gives each member the same privilege of attendance at meetings which he has heretofore enjoyed, and is deemed especially desirable since there has been considerable doubt as to the attendance that might develop at the several meetings if three were held in each month.

PAPERS AND DISCUSSIONS

Members and others who take part in the oral discussions of the papers presented are urged to revise their remarks promptly. Written communications from those who cannot attend the meetings should be sent in at the earliest possible date after the issue of a paper. Written discussion on a given paper will be closed three months after the paper has been published, so that the author's closure can be printed four months after the paper.

All manuscripts submitted for publication should preferably be typewritten, and always double spaced. Drawings and diagrams should be on separate sheets, drawn to a scale suitable for about one-half to one-fourth reduction.

All papers accepted by the Publication Committee are classified by the Committee with respect to their availablity for discussion at meetings.

Papers which, from their general nature, appear to be of a character suitable for oral discussion, will be set down for presentation to a future meeting of the Society, and, on these, oral discussions, as well as written communications, will be solicited.

All papers which do not come under this heading, that is to say, those which from their mathematical or technical nature, in the opinion of the Committee, are not adapted to oral discussion, will not be scheduled for presentation to any meeting. Such papers will be published in the same manner as those which are to be presented at meetings, but written discussions only will be requested for subsequent publication in *Proceedings* and with the paper in the volumes of *Transactions*.

The Board of Direction has adopted rules for the preparation and presentation of papers, which will be found on page 36 of the Year Book for 1921.

* *Proceedings*, Am. Soc. C. E., October, 1921, p. 803.

LOCAL SECTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Section (Constitution Approved by Board, 1905).

Frederick R. Muhs, President; H. D. Dewell, Secretary-Treasurer, 503 Market Street, San Francisco, Cal.

Bi-monthly meetings are held at 6 P. M., at the Engineers' Club, 57 Post Street, on the third Tuesday of February, April, June, August, October, and December, the last being the Annual Meeting. Informal luncheons are held at noon, every Wednesday, at the Engineers' Club. All members of the Society will be gladly welcomed.

Colorado Section (Constitution Approved by Board, 1909).

A. N. Miller, President; Walter L. Drager, Secretary-Treasurer, 412 Tramway Building, Denver, Colo.

Meetings are held on the second Monday of each month, except July and August, usually preceded by an informal dinner. Weekly luncheons are held on Wednesday, at 12.30 P. M., at Daniels and Fisher's. Visiting members of the Society are urged to attend.

Atlanta Section (Constitution Approved by Board, 1912).

J. T. Wardlaw, President; R. S. Fiske, Secretary-Treasurer, 1530 Healey Building, Atlanta, Ga.

Informal luncheons are held on the second Tuesday of each month, at 1.00 P. M., at the Ansley Hotel, to which visiting members of the Society are welcome. Visitors desiring information will telephone the Secretary, "Ivy, 3605."

Baltimore Section (Constitution Approved by Board, 1914).

Ezra B. Whitman, President; George S. Robertson, Sr., Secretary-Treasurer, 1628 Linden Avenue, Baltimore, Md.

Buffalo Section (Constitution Approved by Board, 1921).

A. L. Johnson, President; Bruce L. Cushing, Secretary-Treasurer, 80 West Genesee Street, Buffalo, N. Y.

Central Ohio Section (Constitution Approved by Board, 1921).

F. H. Eno, President; H. D. Bruning, Secretary, 935 Madison Avenue, Columbus, Ohio.

Meetings are held at the rooms of the Engineers' Club of Columbus in the Southern Hotel. The Annual Meeting is held on the second Friday of November and at least two other meetings are held each year, the dates of which are designated by the Board of Direction of the Section.

Cincinnati Section (Constitution Approved by Board, 1920).

Edgar Dow Gilman, President; Alphonse M. Westenhoff, Secretary, 13 East Third Street, Cincinnati, Ohio.

Cleveland Section (Constitution Approved by Board, 1915).

A. V. Ruggles, President; George H. Tinker, Secretary-Treasurer, 516 Columbia Building, Cleveland, Ohio.

Regular meetings are held on the second Wednesday of each month, at 12.15 P. M., in the rooms of the Section, Hotel Winton. Luncheon is served, and all visiting members of the Society are invited to attend.

Connecticut Section (Constitution Approved by Board, 1919).

William J. Backes, President; Clarence M. Blair, Secretary-Treasurer, 785 Edgewood Avenue, New Haven, Conn.

The Annual Meeting is held in April; fortnightly meetings alternate between Hartford and New Haven, Conn. These meetings are informal luncheon gatherings, held usually at noon on Saturday. Members are privileged to invite guests regardless of their affiliation as engineers.

Detroit Section (Constitution Approved by Board, 1916).

H. H. Esselstyn, President; Alex. Linn Trout, Secretary-Treasurer, 2974 Field Avenue, Detroit, Mich.

Regular meetings are held on the second Friday of December, April, and October, the last being the Annual Meeting.

District of Columbia Section (Constitution Approved by Board, 1916).

Gratz B. Strickler, President; James H. Van Wagenen, Secretary-Treasurer, 2001 Sixteenth Street, N. W., Washington, D. C.

Duluth Section (Constitution Approved by Board, 1917).

John L. Pickles, President; Walter G. Zimmermann, Secretary, 203 Wolvin Building, Duluth, Minn.

Regular meetings are held at noon on the third Monday of each month, usually at the Kitchi Gammi Club, to which visiting members of the Society will be welcomed. The Annual Meeting is held on the third Monday in May.

Illinois Section (Constitution Approved by Board, 1916).

A. J. Hammond, President; W. D. Gerber, Secretary-Treasurer, 133 West Washington Street, Chicago, Ill.

Regular meetings are held on the second Monday of March, June, September, and December, the last being the Annual Meeting.

Iowa Section (Constitution Approved by Board, 1920).

J. H. Dunlap, President; R. W. Crum, Secretary, Care, Iowa State Highway Commission, Ames, Iowa.

Kansas City (Mo.) Section (Constitution Approved by Board, 1921).

John V. Hanna, President; Henry C. Tammen, Secretary-Treasurer, 1012 Baltimore Avenue, Kansas City, Mo.

Regular meetings of the Section are held on the first Tuesday of March, June, September, and December, the last being the Annual Meeting. The members of the Kansas City Engineers' Club meet at luncheon at the University Club every Tuesday from 12 M. to 2 P. M., and all members of the Society are invited to attend these luncheons.

Kansas Section (Constitution Approved by Board, 1920).

L. E. Conrad, President; Frank S. Altman, Secretary-Treasurer, 1114 Garfield Avenue, Topeka, Kans.

Los Angeles Section (Constitution Approved by Board, 1913).

Ralph J. Reed, President; Floyd G. Dessery, Secretary, 619 Central Building, Los Angeles, Cal.

Regular monthly meetings are held on the second Wednesday of each month, the Annual Meeting in December. Informal luncheons in connection with the Joint Technical Societies of Los Angeles are held at 12.15 P. M., every Thursday at the Broadway Department Store Café.

Louisiana Section (Constitution Approved by Board, 1914).

Ole K. Olsen, President; F. A. Muth, Secretary, 224 Custom House Building, New Orleans, La.

Regular meetings are held at The Cabildo, New Orleans, La., on the first Monday of January, April, July, and October.

Nashville Section (Constitution Approved by Board, 1921).

Arthur J. Dyer, President; Granbery Jackson, Secretary-Treasurer, 220 Capitol Boulevard, Nashville, Tenn.

Nebraska Section (Constitution Approved by Board, 1917).

Rodman M. Brown, President; Homer V. Knouse, Secretary-Treasurer, 200 City Hall, Omaha, Nebr.

Regular meetings are held on the first Saturday of each month, except July and August. The Annual Meeting is held in Lincoln, Nebr., on the second Friday in January. Visiting members of the Society are especially urged to communicate with the Secretary when in the city.

New York Section (Constitution Approved by Board, 1920).

Nelson P. Lewis, President; J. P. J. Williams, Secretary, 33 West 39th Street, New York City.

Regular meetings are held in the Engineering Societies Building, 29 West 39th Street, New York City, on the third Wednesday of each month, except January and the Annual Meeting in May, held on the second Wednesday of the month.

Northeastern Section (Constitution Approved by Board, 1921).

Frank B. Sanborn, Chairman; Charles W. Banks, Secretary, Wentworth Institute, Boston, Mass.

Northwestern Section (Constitution Approved by Board, 1914).

Charles L. Pillsbury, President; Paul C. Gauger, Secretary, 945 Osceola Avenue, St. Paul, Minn.

Meetings are held bi-monthly, alternating between St. Paul and Minneapolis, on the third Friday of each month.

Oklahoma Section (Constitution Approved by Board, 1920).

Max L. Cunningham, President; R. E. Brownell, Secretary-Treasurer, 402 First National Bank Building, Oklahoma, Okla.

Philadelphia Section (Constitution Approved by Board, 1913).

John Meigs, President; S. C. Hollister, Secretary, 1200 Land Title Building, Philadelphia, Pa.

Regular meetings are held at the Engineers' Club on the first Monday in January, April, and October, the last being the Annual Meeting. Special meetings are also held at times announced in advance.

Pittsburgh Section (Constitution Approved by Board, 1918).

J. N. Chester, President; Nathan Schein, Secretary-Treasurer, 1510 Carson Street, Pittsburgh, Pa.

Portland (Ore.) Section (Constitution Approved by Board, 1913).

M. E. Reed, President; C. P. Keyser, Secretary, 318 City Hall, Portland, Ore.

Meetings are held regularly on the third Friday of each month. All members of the Society in any grade are cordially invited to attend.

Providence (R. I.) Section (Constitution Approved by Board, 1920).

Sydney Wilmot, Chairman; Robert L. Bowen, Secretary-Treasurer, 26 Sycamore Street, Providence, R. I.

The Section regularly holds meetings jointly with the Structural and Municipal Sections of the Providence Engineering Society, at the Society Rooms, 29 Waterman Street, on the fourth Tuesday of each month, from September to May. The Annual Meeting is held in May. All visiting members of the Society are cordially invited to attend these meetings.

St. Louis Section (Constitution Approved by Board, 1914).

E. B. Fay, President; William C. E. Becker, Secretary-Treasurer, 426 City Hall, St. Louis, Mo.

The Annual Meeting is held on the fourth Monday in November. Two meetings each year for the presentation and discussion of technical papers are held in the Auditorium of the Engineers' Club, and are open to members of the Associated Societies. Other "get-together" meetings are held regularly for dinner or luncheon on the fourth Monday of each month except July, August, and November.

San Diego Section (Constitution Approved by Board, 1915).

F. J. Grumm, President; J. Y. Jewett, Secretary-Treasurer, Administration Building, Balboa Park, San Diego, Cal.

Regular meetings are held on the third Tuesday of each month at the Chamber of Commerce. Visiting members of the Society are invited to attend.

Seattle Section (Constitution Approved by Board, 1913).

T. E. Phipps, President; Frank H. Fowler, Secretary-Treasurer, 1319 L. C. Smith Building, Seattle, Wash.

Regular meetings, with luncheon, are held at the Engineers' Club, on the last Monday of each month. All members in any grade of the Society are cordially invited to attend, and if located in this District for any length of time, their membership in the Section will be appreciated.

Spokane Section (Constitution Approved by Board, 1914).

E. G. Taber, President; Charles E. Davis, Secretary-Treasurer, 401 City Hall, Spokane, Wash.

Meetings are held on the second Friday of each month. These meetings are noonday luncheons at Davenport's, and all visiting members of the Society are invited to attend.

Texas Section (Constitution Approved by Board, 1913).

E. B. Cushing, President; E. N. Noyes, Secretary, 1107 Dallas County Bank Building, Dallas, Tex.

Utah Section (Constitution Approved by Board, 1916).

W. R. Armstrong, President; H. S. Kleinschmidt, Secretary-Treasurer, 222 Felt Building, Salt Lake City, Utah.

The Annual Meeting is held on the first Wednesday in April. The time of other meetings is not fixed, but this information will be furnished on application to the Secretary.

STUDENT CHAPTERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS*

Leland Stanford, Jr., University Student Chapter, Organized 1920.

R. I. Hill, President; John H. Colton, Corresponding Secretary, Box 121, Stanford, Cal.

Alabama Polytechnic Institute Student Chapter, Organized 1921.

Alfred D. Boyd, Secretary, Alabama Polytechnic Institute, Auburn, Ala.

Braune Civil Engineering Society (University of Cincinnati) Student Chapter, Organized 1920.

John W. Guilday, President; C. A. Harrell, Secretary of Section 10; R. Blickensderfer, Secretary of Section 20; University of Cincinnati, Cincinnati, Ohio.

California Institute of Technology Student Chapter, Organized 1921.

W. M. Taggart, President; Douglas A. Stromsoe, Secretary, California Institute of Technology, Pasadena, Cal.

Cornell University Student Chapter, Organized 1921.

T. D. Finn, Jr., President; James Hannigan, Secretary-Treasurer, Lincoln Hall, Cornell University, Ithaca, N. Y.

Drexel Institute Student Chapter, Organized 1920.

C. V. Nishwitz, Chairman; Raymond Radbill, Secretary, Drexel Institute, Philadelphia, Pa.

Iowa State College Student Chapter, Organized 1920.

Raymond L. Whammel, President; G. La Verne Day, Secretary, Iowa State College, Ames, Iowa.

Johns Hopkins University Student Chapter, Organized 1921.

Eric M. Arndt, President; Melvin E. Scheidt, Secretary, Box 566, Homewood, Baltimore, Md.

Massachusetts Institute of Technology Student Chapter, Organized 1921.

D. H. McCreery, President; T. S. Wray, Secretary, Massachusetts Institute of Technology, Cambridge, Mass.

New York University Student Chapter, Organized 1921.

William J. Kiehnle, President; George H. Martin, Jr., Secretary, New York University, University Heights, New York City.

Oregon State Agricultural College Student Chapter, Organized 1921.

Richard D. Slater, President; Wilbur H. Welch, Secretary, Oregon State Agricultural College, Corvallis, Ore.

Pennsylvania State College Student Chapter, Organized 1920.

Arthur H. McFadden, President; William W. Seltzer, Secretary, Pennsylvania State College, State College, Pa.

Polytechnic Institute of Brooklyn Student Chapter, Organized 1921.

W. C. Hanning, President; S. Lordi, Secretary, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

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* By a recent ruling of the Board of Direction, the minimum membership of a Student Chapter has been fixed at 12 instead of 20.

Purdue University Student Chapter, Organized 1921.

Donald A. Leach, President, 208 Fowler Avenue, West Lafayette, Ind.

Rensselaer Polytechnic Institute Student Chapter, Organized 1920.

William Minot Thomas, President; Earl D. Hopkins, Secretary, 147 Eighth Street, Troy, N. Y.

Rose Polytechnic Institute Student Chapter, Organized 1921.

Robert Cash, President; F. Ray Martin, Secretary-Treasurer, Rose Polytechnic Institute, Terre Haute, Ind.

Rutgers College Student Chapter, Organized 1921.

L. C. Kuhl, President; A. C. Ely, Secretary, 105 Winants Hall, Rutgers College, New Brunswick, N. J.

State University of Iowa Student Chapter, Organized 1921.

James Fred Phillips, President; Louis E. Bagg, Secretary, State University of Iowa, Iowa City, Iowa.

Swarthmore College Student Chapter, Organized 1921.

Frank Lemke, President; H. Chandler Turner, Jr., Secretary, Swarthmore College, Swarthmore, Pa.

Syracuse University Student Chapter, Organized 1921.

Arthur V. Dollard, Secretary, College of Applied Science, Syracuse University, Syracuse, N. Y.

University of California Student Chapter, Organized 1921.

H. G. Gerdes, Secretary, Care, Prof. Charles Derleth, Jr., College of Civil Engineering, University of California, Berkeley, Cal.

University of Colorado Civil Engineering Society Student Chapter, Organized 1920.

Herbert Altvater, President; Charles Bowden, Secretary, 1229 University Avenue, Boulder, Colo.

University of Illinois Student Chapter, Organized 1921.

A. L. R. Sanders, President; M. E. Jansson, Secretary, University of Illinois, Urbana, Ill.

University of Kansas Student Chapter, Organized 1921.

W. W. Hoagland, President; Waldo G. Bowman, Secretary, 1106 Ohio Street, Lawrence, Kans.

University of Kentucky Student Chapter, Organized 1921.

H. J. Beam, President; H. E. Glenn, Secretary-Treasurer, 348 Harrison Avenue, Lexington, Ky.

University of Maine Student Chapter, Organized 1921.

George H. Ferguson, Jr., Secretary, University of Maine, Orono, Me.

University of Minnesota Student Chapter, Organized 1921.

C. L. Swanson, President, 1716 Tyler Street, N. E., Minneapolis, Minn.

University of Nebraska Student Chapter, Organized 1921.

J. E. Applegate, President; W. H. Mengel, Secretary, University of Nebraska, Lincoln, Nebr.

University of North Carolina Student Chapter, 1921.

H. G. Baity, President; L. I. Lassiter, Secretary, University of North Carolina, Chapter Hill, N. C.

University of Pennsylvania Student Chapter, Organized 1920.

Charles W. Foppert, President; Fred Welchy, Secretary, University of Pennsylvania, Philadelphia, Pa.

University of Pittsburgh Student Chapter, Organized 1921.

L. W. Fletcher, President; J. M. Daniels, Secretary, University of Pittsburgh, Pittsburgh, Pa.

University of Texas Student Chapter, Organized 1921.

W. H. D. Taylor, President; Phil M. Ferguson, Secretary, 2505 Guadalupe Street, Austin, Tex.

University of Washington Student Chapter, Organized 1921.

B. W. Brown, President; G. E. Large, Secretary, 4518 Eleventh Avenue, N. E., Seattle, Wash.

University of Wisconsin Student Chapter, Organized 1921.

Herbert Wheaton, President; Olaf N. Rove, Secretary, University of Wisconsin, Madison, Wis.

Virginia Military Institute Student Chapter, Organized 1921.

Benjamin F. Parrott, President; R. G. Hunt, Secretary-Treasurer, Virginia Military Institute, Lexington, Va.

Washington University Collimation Club Student Chapter, Organized 1920.

William D. Rolfe, President; Erwin Bloss, Secretary, Washington University, St. Louis, Mo.

West Virginia University Student Chapter, Organized 1921.

J. E. Wheeler, President; Milton Jarrell, Secretary, 113 Beverly Avenue, Morgantown, W. Va.

Yale University Student Chapter, Organized 1921.

W. S. Moore, President; T. T. McCrosky, Secretary, Sheffield Scientific School, Yale University, New Haven, Conn.

PRIVILEGES OF ENGINEERING SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Members of the American Society of Civil Engineers will be welcome in the Reading Rooms and at the meetings of many engineering societies in all parts of the world. A list of such societies will be found on pages 48, 49, and 50 of the Year Book of the Society for 1921.

NEW BOOKS*

(From December 1st to December 31st, 1921)

The statements made in these notices are taken from the books themselves, and this Society is not responsible for them.

DONATIONS TO ENGINEERING SOCIETIES LIBRARY

RADIOACTIVITY AND RADIOACTIVE SUBSTANCES.

By J. Chadwick. (Technical Primers.) Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 111 pp., illus., 6 x 4 in., cloth. 85 cents.

This clear, accurate account of radioactive phenomena, by one with first hand knowledge of the facts, furnishes the beginner with a simple, concise, accurate introduction to the subject.

RADIO QUESTIONS AND ANSWERS.

By Arthur R. Nilson. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1921. 86 pp., illus., 7 x 5 in., boards. $1.00.

A quiz compend for those preparing for examination. Treats of theory, apparatus, laws, and regulations, etc.

MÉMOIRES SUR L'ÉLECTROMAGNÉTISME ET L'ÉLECTRODYNAMIQUE.

By André-Marie Ampère. 110 pp., illus., 7 x 4 in., paper. 3 francs.

The two classic memoirs in this little book are that in which Ampère described his experiments on the action exerted on an electric current by another current or a magnet, and the one giving the results of his study of the formula expressing the attraction and repulsion between two infinitely small elements of two conductors. They are here reprinted from the best text, in attractive form.

EMISSION OF ELECTRICITY FROM HOT BODIES.

By O. W. Richardson. (Monographs on Physics.) Second Edition. Lond. and N. Y., Longmans, Green and Co., 1921. 320 pp., 9 x 6 in., cloth. $5.25.

This work, one of a series of monographs in physics edited by Sir J. J. Thomson and Professor Horton, deals with the emission of positive and negative electricity from hot bodies. The author was one of the first investigators of this subject and a large part of our knowledge is due to his work. As a consequence, this volume contains a clear, up-to-date account of the subject written by one who appreciates fully the experimental difficulties and the adequacy of the theories proposed. This edition has been extended and thoroughly revised.

FILES AND FILING.

By Ch. Fremont. Translated under the Supervision of George Taylor. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1920. 148 pp., illus., 11 x 9 in., cloth. $7.50.

In a brief readable account, M. Fremont describes the origin and evolution of the file from the earliest times to modern days, the origin of file-cutting machines, the methods of filing, and the influence of various factors on efficiency, the cut of files, their use, and the methods of testing. The technical sections include the results of much scientific investigation in the author's laboratory. The volume will be interesting not only to makers and users of files, but also to students of the history of machines. The text is fully illustrated.

AUTOMOBILE ENGINEERING.

Chic., American Technical Society, 1920. 6 vol., illus., 8 x 6 in., fabrikoid. $29.80.

This is a course of self-instruction and a book of reference covering the maintenance and operation of automobiles of all kinds. The information given is presented clearly and without mathematics, and the subject-matter is illustrated by many cuts and drawings. Earlier editions were entitled "Cyclopedia of Automobile Engineering".

AUTOMOBILE AND AIRCRAFT ENGINES.

By Arthur W. Judge. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 642 pp., illus., tab., 8 x 6 in., cloth. $9.50.

The author presents, in as concise and elementary form as possible, an account of the theory of the lighter-fuel type of high-speed internal combustion engine, and of the

* Unless otherwise specified, books in this list have been donated by the publishers.

experimental results obtained from it. The book is intended especially for engineers and designers of automotive machinery. It is nearly twice the size of its predecessor, the additions being chiefly experimental data obtained in recent years.

COMPTEURS DE VAPEURS.

By E. Hoehn. Paris, Ch. Béranger, 1921. 34 pp., illus., 9 x 6 in., paper. 2 francs.

This pamphlet by the Chief Engineer of the Swiss Association of Boiler Owners describes the theory and operation of ordinary and recording steam meters, with notes on the advantages and disadvantages of the different types.

TURBINES.

By A. E. Tompkins. Third Edition, Revised. Lond., Soc. for Promoting Christian Knowledge; N. Y., The Macmillan Co., 1921. 180 pp., illus., 8 x 5 in., cloth. $2.50.

The author describes, in simple, non-mathematical fashion, good modern practice in the construction and working arrangement of water turbines, turbine pumps, and steam turbines. Useful to students and to mén engaged in fitting and repairing turbines.

MATERIAL-HANDLING CYCLOPEDIA.

Compiled and Edited by Roy V. Wright, John G. Little, and Robert C. Augur. N. Y., Simmons-Boardman Publishing Co., 1921. 846 pp., illus., 12 x 9 in., cloth. $10.00.

This Cyclopædia is designed to present comprehensively definitions, descriptions, illustrations, applications, and methods of operation of industrial devices for handling materials. The text covers hoisting machinery, package conveyors, loose material conveyors, elevators, trackless transportation, industrial rail transportation, and handling systems. Each section has been prepared by a specialist.

VORRICHTUNGEN IM MASCHINENBAU NEBST ANWENDUNGSBEISPIELEN.

By Otto Lich. Berlin, Julius Springer, 1921. 507 pp., illus., diagrams, 9 x 6 in., cloth. 120 marks.

This volume contains a detailed study of clamps, fixtures, and jigs for machine tools and of their application to increase output. All the customary operations, boring, slotting, planing, milling, forging, hardening, etc., are considered. There is also a section on the savings obtainable by such attachments and one on maintenance and repair. The book is intended for machine builders, and for operators who wish to increase the efficiency of existing equipment. The author presents his book as a contribution toward the reconstruction of the German metal industries, which he believes will be possible only through the greatest possible economy of time and labor.

MANUAL OF DETERMINATIVE MINERALOGY.

By J. Volney Lewis. Third Revised and Enlarged Edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 298 pp., tables, 9 x 6 in., cloth. $3.00.

In this edition the blowpipe tables have been thoroughly revised and recast, and a new classification of minerals based on their physical properties has been added. The blowpipe tables include about 355 minerals and the physical classification about 290. The physical classification differs from common practice by eliminating luster as a basis of classification. The book is planned with reference to the requirements of the geologist and engineer, as well as the student.

ECONOMICS OF PETROLEUM.

By Joseph E. Pogue. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 375 pp., pl., illus., 9 x 6 in., cloth. $6.00.

The purpose of this book is to present the more important economic facts relating to petroleum, to interpret the changes that are taking place in the industry, and to forecast the future trend of these changes. The book is intended for those engaged in the petroleum industry as engineers or producers, and for those engaged in industries dependent on petroleum products, and contains useful information on our resources, the trend of development, production and refining, transportation, prices, trend of consumption, and similar topics.

PRACTICAL LEAST SQUARES.

By Ora Miner Leland. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1921. 237 pp., 9 x 6 in., cloth. $3.00.

This textbook is based on the course given to students of Civil Engineering at Cornell University and is designed particularly for use in short courses of instruction and by engineers and scientists in connection with their private practice. It will not replace more elaborate treaties, but the author hopes it will introduce the student directly to the simpler methods of solving the ordinary problems in adjustment.

TREATISE ON THE INTEGRAL CALCULUS; VOL. 1.

By Joseph Edwards. Lond., Macmillan and Co., Ltd., 1921 907 pp., 9 x 6 in., cloth. $16.00. (Gift of The Macmillan Co., N. Y.)

This is the first volume of an extensive treatise on the subject for advanced students. In it the author attempts to collect all the information necessary to give the reader a good working knowledge of integral calculus, both practically and theoretically, and to place this information before him as clearly as possible, with an abundance of illustrative examples and instances of the application of the principles explained.

GRAPHICAL ANALYSIS; A TEXTBOOK ON GRAPHIC STATICS.

By William S. Wolfe. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1921. 374 pp., illus., 9 x 6 in., cloth. $4.00.

The subject-matter of this book is based on the author's courses in the University of Illinois, and deals with the analysis of stresses rather than with design or the computation of loads, but includes some consideration of these questions also.

LA PHYSIQUE THEORIQUE NOUVELLE.

By Julien Pacotte. Paris, Gauthier-Villars et Cie., 1921. 182 pp., 10 x 6 in., paper. 12 francs.

The new physics in question had its origin in Lorentz's electrodynamics, which is the definitive form of Maxwell's theory; its most advanced theories are due to Einstein; it has to do with relativity, with the energy equivalent of two masses of matter, with atoms of energy. The author presents an historical, critical, non-mathematical account of the theories that underlie modern ideas, suitable as an introduction to the subject.

LA LOI DE NEWTON EST LA LOI UNIQUE.

By Max Franck. Paris, Gauthier-Villars et Cie, 1921. 158 pp., 10 x 6 in., paper. 12.50 francs.

The question considered in this book is whether it is possible, with present knowledge, to formulate the law governing the mechanism of the universe. On two postulates, that all potential energy resides in the absolute space of the physicist, and that all matter is formed of an element of inertia movable in space, the author erects a hypothesis, and compares its consequences with known facts, to determine how nearly the two agree. The first consequence is the confirmation of Newton's law, which may now be given its exact interpretation; this is the reason for the title given the book. The author's theory uses only the notions of space, time, force, and inertia admitted in Euclidean geometry and mechanics.

ESSAI PHILOSOPHIQUE SUR LES PROBABILITES.

By Pierre-Simon Laplace. (Maîtres de la Pensée Scientifique.) Paris, Gauthier-Villars et Cie, 1921. 2 vol., 7 x 4 in., paper. 3 francs per vol.

In this famous book, Laplace presented, without resorting to analysis, the principles and general results of the theory of probabilities, and applied them to some of the most important questions of life. The present edition reproduces the best text in a cheap, convenient edition.

COURS DE MECANIQUE RATIONELLE.

By Louis Roy. Paris, Gauthier-Villars et Cie., 1921. 259 pp., 10 x 6 in., paper.

This volume, with the author's previous book on graphic statics and strength of materials, forms a course of instruction in mechanics for students of engineering. The present work is intended for beginners and, therefore, is confined to the elements of mechanics, which it presents so that students will have the grounding necessary for the study of applied mechanics, general physics, and electrical engineering.

PUBLIC OPINION AND THE STEEL STRIKE;

Supplementary Reports of the Investigators to the Commission of Inquiry, the Interchurch World Movement. N. Y., Harcourt, Brace and Co., 1921. 346 pp., 8 x 6 in., cloth. $2.50.

The report on the steel strike of 1919, made by the Commission of Inquiry, Interchurch World Movement, announced that a second volume would contain supplementary reports. The present volume, the work of the investigators, contains over half the supplementary reports, published not only as supporting documents to the Steel Report, but also as separate fuller studies of special phases of the investigation.

MARKET ANALYSIS.

By Percival White. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1921. 340 pp., illus., 8 x 6 in., cloth. $3.50.

This volume is intended as a guide for manufacturers, sales managers, engineers, and others interested in the analysis and organization of markets. The book contains, the author states, all the instructions necessary for conducting a market survey.

CANE SUGAR.

By Noël Deerr. Second Edition. Lond., Norman Rodger, 1921. 644 pp., pl., illus., 10 x 7 in., cloth. 42s.

The author of this work, writing from long experience in the cane-sugar industry, acquired in the more important sugar-producing districts of the world, gives an account of the salient points of the industry, with a detailed treatment of its more important aspects. The botany, agriculture, and pathology of the sugar cane, sugar-house practice, and the control of the processes are given careful treatment. Many colored plates are included, and there are numerous lists of references and an extensive bibliography. This edition has been reset and enlarged.

BLEACHING.

By J. Merritt Matthews. N. Y., Chemical Catalog Co., Inc., 1921. 676 pp., illus., 9 x 6 in., cloth. $8.00.

The author has attempted in this book to bring together under one subject the main facts relating to the bleaching of a variety of materials, and to discuss these facts from the practical point of view of the textile chemist and the actual operative in the mill. The volume is restricted to the direct subject of bleaching and the necessary preliminary operations, scouring, boiling-out, etc. The greater part of the book is concerned with the bleaching of textiles, but other vegetable fibers and materials, such as straw, leather, and bone, are also discussed.

SOAPS AND PROTEINS; THEIR COLLOID CHEMISTRY.

By Martin H. Fischer, with the Collaboration of George D. McLaughlin and Marian O. Hooker. N. Y., John Wiley & Sons, Inc., 1921. 272 pp., illus., tab., 9 x 6 in., cloth. $4.00.

This volume appeals to those interested in colloid chemistry, to soap-makers, and to physiologists. It presents the results of an extended study of the colloid chemistry of soaps, undertaken for the elucidation of various biological questions, but which also gave information useful to colloid chemists and soap manufacturers.

FOOD PRODUCTS.

By E. H. S. Bailey. Second Revised Edition. Phila., P. Blakiston's Son & Co., 1921. 551 pp., illus., 8 x 5 in., cloth. $2.50.

Professor Bailey has collected the material distributed through a multitude of books and scientific reports on the important foods and beverages of the world, their sources, methods of preparation for market, packing, preserving and shipping, composition, nutrient and dietetic value, and their use. These data are summarized in a volume of convenient size.

ELEMENTARY CHEMICAL MICROSCOPY.

By Emile Monnin Chamot. Second Edition, Partly Rewritten and Enlarged. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 479 pp., illus., 9 x 6 in., cloth. $4.25.

A work calling attention to the possibilities of the microscope as an aid to the chemist. Intended to serve as an introduction to the microscope and its accessories as tools for the chemist, and as a basis for advanced work in specific fields.

INDUSTRIAL HYDROGEN.

By Hugh S. Taylor. (American Chemical Society, Monograph Series). N. Y., Chemical Catalog Co., Inc., 1921. 210 pp., illus., 9 x 6 in., cloth. $3.50.

The development of knowledge in all branches of science has been so rapid in recent years, and the fields covered have been so varied, that it is difficult for any individual to keep in touch with the progress in branches of science other than his own specialty, and much time is often necessary to co-ordinate the knowledge available on a single topic. The monographs appearing under the auspices of the American Chemical Society are intended to ameliorate this condition by providing concise, readable accounts of important subjects, written by men who have spent years in the study of them. The present monograph outlines the fundamental principles and essential chemical facts of the industry of hydrogen production, tracing the steps by which the present status has been reached, describing that status in detail, and indicating probable future developments. While the chemical problems have been emphasized, the data needed by the engineer in plant design are also present.

DIE NATÜRLICHEN UND KÜNSTLICHEN ASPHALTE.

By J. Marcusson. Leipzig, Wilhelm Engelmann. 262 pp., illus., 9 x 6 in., cloth. 34 marks.

The first section of this work discusses the occurrence, composition, properties, and uses of asphalt, tars, and pitches, and gives methods for their physical and chemical examination. Section 2 treats of asphalt products, sheet asphalt, asphalt cements, roofing papers, insulating materials, paints, etc., and pays special attention to methods for testing them. A list of the more important German, French, and British patents is included. The book is based on investigations at the National Testing Laboratory. The methods of testing have given satisfaction during long use.

RAILROADS OF MEXICO.

By Fred Wilbur Powell. Bost., Stratford Co., 1921. 226 pp., 8 x 5 in., cloth. $2.00.

The author has endeavored to fill the lack of authentic information on the Mexican railroad situation by a study of the fragmentary data available. The book is divided into three sections: The first contains an account of transportation during the period following the Diaz régime and of the situation to-day. Part 2 is a summary of the development of the great Mexican system of land transportation, and Part 3 presents the author's conclusions. An extensive bibliography is given.

ELEMENTS OF ILLUMINATING ENGINEERING.

By A. P. Trotter. (Technical Primers.) Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 103 pp., illus., 6 x 4 in., cloth. 85 cents.

This primer, intended as an introduction to the elements of the subject, gives a clear concise account of the theoretical principles, and of modern practice in the distribution and measurement of illumination.

FIRE PREVENTION AND FIRE PROTECTION AS APPLIED TO BUILDING CONSTRUCTION.

By Joseph Kendall Freitag. Second Edition, Revised. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 1 038 pp., illus., 7 x 4 in., fabrikoid. $5.00.

This new edition has been extensively revised and the changes in design, construction, and equipment which have been approved during the nine years which have elapsed since the first edition, have been included. The work is intended to present, in a form convenient for quick reference, the present status of the subject.

TASCHENBUCH FÜR BAUINGENIEURE.

By Max Foerster. Vierte Auflage. Berlin, Julius Springer, 1921. 2 vol., illus., diagrams, tab., 8 x 5 in., cloth.

The field covered in this work is a wide one, including the construction of public works, buildings, bridges, railroads, and machinery. It has been prepared by a number of specialists under Dr. Foerster's guidance, and its popularity is indicated by the appearance of four editions within ten years.

DONATIONS TO THE READING ROOM

SOPHOMORE ENGLISH FOR ENGINEERS.

By D. B. Coffer. No place, copyright 1921. 20 pp., 9 x 6 in., paper. (Gift of the Author).

This pamphlet, it is stated, is designed for the guidance of engineering students who desire to acquire correct and forcible English. The subject-matter falls into four divisions, outside reading, oral reports, report writing, and written tests.

MEMBERSHIP

(From December 7th, 1921, to January 3d, 1922)

ADDITIONS

HONORARY MEMBERS

Name and Address		Date of Membership.
FOCH, FERDINAND. Maréchal de France, Paris, France		Dec. 6, 1921
SCHNEIDER, CHARLES PROSPER EUGENE. (Schneider & Cie.), 42 rue d'Anjou, Paris, France		Oct. 10, 1921

MEMBERS

Name and Address		Date of Membership.
BLUE, FREDERICK KELLOGG. Mech. Engr., Ford, Bacon & Davis, 1569 Masonic Ave., San Francisco, Cal		Nov. 21, 1921
BUCK, ROSS JUDSON. Director of Public Works, Muskegon, Mich	Jun. Assoc. M. M.	June 30, 1911 Nov. 28, 1916 July 11, 1921
COUSINS, HOWARD EVERETT. Asst. Dist. Engr., Lockwood, Greene & Co., Boston (Res., 44 Lombard Terrace, Arlington), Mass.		Nov. 21, 1921
CROOKS, ARCHIE BEDELL. 169 Elwood Ave., Newark, N. J		July 11, 1921
FISK, JAMES HARRIS PLINY. (Douglas, Corey & Fisk), Box 205, Walsenburg, Colo		Nov. 21, 1921
FOX, CHARLES KIRBY. Engr. and Contr. (Ranch Development Co.), 435 I. W. Hellman Bldg., Los Angeles, Cal	Assoc. M. M.	May 28, 1912 Nov. 21, 1921
HEIDEL, CHARLES SUMNER. State Engr.; Asst. Engr., Water Resources Branch, U. S. Geological Survey, Helena, Mont	Jun. Assoc. M. M.	July 2, 1913 Oct. 14, 1919 Nov. 21, 1921
HENRY, EARLE UNDERWOOD. Cons. Engr. (David M. Duller), 320 Beatty Bldg. (Res., 2411 Main St.), Houston, Tex	Assoc. M. M.	Nov. 3, 1915 Oct. 12, 1921
HILL, NORMAN HADEN. 911 State Life Bldg., Indianapolis, Ind	Assoc. M. M.	Jan. 13, 1919 Nov. 21, 1921
KOCH, OSCAR HENRY. Cons. Engr. (Koch & Fowler), 606 Sumpter Bldg., Dallas, Tex	Assoc. M. M.	April 14, 1919 Nov. 21, 1921
LILLY, HENRY MARVIN. Box 383, Newbern, N. C		Oct. 10, 1921
PAYNE, JAMES HENRY. Office Engr. and Chf. Draftsman, L. A. & S. L. R. R., 543 Pacific Elec. Bldg., Los Angeles, Cal	Assoc. M. M.	Feb. 5, 1908 Nov. 21, 1921
PECKHAM, FRED HOWLAND. Cons. Engr. (Peckham & Wilkins); Cons. Engr. (Peckham & Sutton); Cons. Engr. (Peckham, Sutton & James), 225½ West Grand Ave., Oklahoma, Okla		Nov. 21, 1921
SEYMOUR, HORATIO. Contr. Engr., 514 Idaho Ave., Santa Monica, Cal	Jun. Assoc. M. M.	April 2, 1913 Mar. 2, 1915 Nov. 21, 1921

ASSOCIATE MEMBERS

Name and Address		Date of Membership.
ADAMS, BENJAMIN WARREN. County Surv., Dawson County, Lock Drawer D, Glendive, Mont		July 11, 1921
ADAMSON, ARTHUR QUINTIN. Secy. of Bldg. Constr., National Committee, Y. M. C. A. of China, 20 Museum Rd., Shanghai, China		Oct. 10, 1921

ASSOCIATE MEMBERS—(*Continued*)

		Date of Membership.
BEDELL, FLOYD CARSON. Lieut. (Junior Grade), C. E. C., U. S. N., Care, Public Works Officer, U. S. Naval Station, Pearl Harbor, Hawaii	Jun. Assoc. M.	Jan. 19, 1920 Nov. 21, 1921
BURTON, HUNTER HANCOCK, Manassas, Va		Nov. 21, 1921
BUTTON, MAX LAWRENCE. 9 Carleton Rd., Belmont, Mass		Nov. 21, 1921
CRADDOCK, FRANKLIN HARPER. City Hall (Res., 824 H St.), Centralia, Wash	Jun. Assoc. M.	Sept. 10, 1918 Oct. 10, 1921
CUMMINS, ANDREW ADAIR. With Nebraska Cement Co., Superior, Nebr.		Sept. 12, 1921
DIXON, LEON SNELL. Asst. Engr., Northern Paper Co., Millinocket (Res., Bangor), Me		Nov. 21, 1921
GABELMAN, WILLIAM EDWARD. Care, Manila Eng. Co., Inc., 1102 Castillejos, Tanduay, Manila, Philippine Islands		Oct. 10, 1921
GAMSU, FREDERICK CONRAD. Ten Eyck Hotel, Room 853, Albany, N. Y	Jun. Assoc. M.	June 16, 1919 Oct. 11, 1921
HAWORTH, MACK ELLIOTT. Chf. Draftsman and Asst. to Chf. Engr., Hillman Coal & Coke Co., 2307 First National Bank Bldg., Pittsburgh, Pa		Sept. 12, 1921
HOFF, WILLIAM HENRY. City Engr. and Surv., 90 Morgan Pl., North Arlington, N. J		Nov. 21, 1921
KNIGHTS, PHILIP WOODBRIDGE. City Engr., Box 292, El Centro, Cal.		Sept. 12, 1921
O'BRIEN, JAMES BRUCE. 1403 South Cameron St., Harrisburg, Pa.	Jun. Assoc. M.	Sept. 10, 1918 Nov. 21, 1921
PAXSON, GLENN STUART. Res. Engr., Oregon State Highway Comm., 414 Meridian St., Newberg, Ore		Nov. 21, 1921
ROBERTS, EMORY DOUGLAS. Instr. Civ. Eng., Oregon Agricultural Coll., 2719 Arnold Way, Corvallis, Ore		Nov. 21, 1921
ROLLMAN, OTTO CHARLES. Div. Engr., Wisconsin Highway Comm., 819 North Ashland, Green Bay, Wis		Nov. 21, 1921
WHIPPLE, STEPHEN KNIGHT. Civ. Eng. Draftsman, Eng. Dept., Standard Oil Co., Box 372, Burlingame, Cal		Sept. 12, 1921
WOODLE, BERNON TISDALE. Irvington-on-Hudson, N. Y.	Jun. Assoc. M.	Sept. 2, 1914 Nov. 21, 1921
YOUNG, ELMER VINCENT. Care, J. B. McCrary Eng. Corporation, Atlanta, Ga		July 11, 1921

JUNIORS

BAUMAN, PAUL. Surv. and Designer, Beckman & Linden Eng. Corporation, 517 East Adams St., Phoenix, Ariz	Nov. 21, 1921
DOWNEY, JOHN JONES. Care, Charles T. Main, 201 Devonshire St., Boston, Mass	July 6, 1920
VAWTER, ROBERT. Eskdale, W. Va	Nov. 21, 1921

RESIGNATIONS

MEMBERS

	Date of Resignation.
FITCH, SQUIRE EARNEST	Dec. 31, 1921

ASSOCIATE MEMBERS	Date of Resignation.
Hazen, Ralph William	Dec. 31, 1921
Poole, John Hudson	Dec. 31, 1921

JUNIOR	
James, Robert Lane	Dec. 31, 1921

DEATHS

Booth, William Henry. Elected Member, July 4th, 1888; died November 12th, 1921.

Farrar, Hartwell Prentice. Elected Member, November 1st, 1893; died December 16th, 1921.

Gibboney, Franklin Lincoln. Elected Associate Member, October 31st, 1911; died November 20th, 1920.

Norboe, Paul Maningham. Elected Member, November 1st, 1905; died November 15th, 1921.

Owen, James. Elected Member, September 15th, 1869; died July, 1921.

Parker, Maurice Stiles. Elected Member, February 5th, 1890; died June 3d, 1921.

Phillips, Hiram. Elected Associate Member, January 3d, 1894; Member, November 3d, 1897; died December 22d, 1921.

Prior, Charles Henry. Elected Member, March 1st, 1882; died November 13th, 1921.

Seddon, James Alexander. Elected Member, November 2d, 1898; died October 1st, 1921.

Wells, Joseph Agur. Elected Affiliate, January 7th, 1896; died December 5th, 1921.

Wimmer, Sebastian. Elected Member, March 2d, 1881; died November 30th, 1921.

Total Membership of the Society, January 3d, 1922,
10 345.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST

(December 1st to December 30th, 1921)

NOTE.—*This list is published for the purpose of placing before the members of this Society the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS

In the subjoined list of articles, references are given by the number prefixed to each journal in this list.

(2) *Journal*, Engrs. Club of Phila., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 60c.
(4) *Journal*, Western Soc. of Engrs., Chicago, Ill., 50c.
(5) *Journal*, Eng. Inst. of Canada, Montreal, Que., Canada.
(6) *Journal*, Am. Inst. of Archts., Washington, D. C., 50c.
(7) *Gesundheits Ingenieur*, Munich, Germany.
(8) *Stevens Indicator*, Hoboken, N. J., 50c.
(9) *Industrial Management*, New York City, 35c.
(11) *Engineering* (London), W. H. Wiley, 432 Fourth Ave., New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News-Record*, New York City, 25c.
(15) *Railway Age*, New York City, 25c.
(16) *Engineering and Mining Journal*, New York City, 25c.
(17) *Electric Railway Journal*, New York City, 20c.
(18) *Railway Review*, Chicago, Ill., 25c.
(20) *Iron Age*, New York City, 50c.
(21) *Railway Engineer*, London, England, 1s 2d.
(22) *Iron and Coal Trades Review*, London, England, 6d.
(24) *American Gas Journal*, New York City, 10c.
(25) *Railway Mechanical Engineer*, New York City, 35c.
(26) *Electrical Review*, London, England, 4d.
(27) *Electrical World*, New York City, 25c.
(28) *Journal*, New England Water-Works Assoc., Boston, Mass., $1.25.
(29) *Journal*, Royal Soc. of Arts, London, England, 6d.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium.
(31) *Annales* de l'Assoc. des Ingenieurs Sortis des Ecoles Speciales de Gand. Brussels, Belgium.
(32) *Memoirs et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France, 1 fr.
(36) *Cornell Civil Engineer*, Ithaca, N. Y.
(40) *Zentralblatt der Bauverwaltung*, Berlin, Germany, 60 pfd.
(41) *Elektrotechnische Zeitschrift*, Berlin, Germany.
(42) *Journal*, Am. Inst. Elec. Engrs., New York City, $1.
(43) *Annales des Ponts et Chausées*, Paris, France.
(45) *Coal Age*, New York City, 20c.
(46) *Scientific American*, New York City, 35c.
(47) *Mechanical Engineer*, Manchester, England, 3d.
(48) *Zeitschrift*, Verein DeutscherIngenieure, Berlin, Germany.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Düsseldorf, Germany.
(53) *Zeitschrift*, Oesterreichischer, Ingenieur und Architekten-Verein, Vienna, Austria, 70h.
(54) *Transactions*, Am. Soc. C. E., New York City, $16.
(55) *Mechanical Engineering*: Journal, Am. Soc. M. E., New York City, 40c.
(57) *Colliery Guardian*, London, England, 5d.
(58) *Proceedings*, Engrs.' Soc. of W. Pa., 2511 Oliver Bldg., Pittsburgh, Pa., 50c.
(59) *Proceedings*, American Water Works Assoc., Baltimore, Md.
(60) *Municipal and County Engineering*, Indianapolis, Ind., 25c.
(61) *Proceedings*, Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *Forging and Heat Treating*, Thaw Bldg., Pittsburgh, Pa., 10c.
(63) *Minutes of Proceedings*, Inst. C. E., London, England.
(64) *Power*, New York City, 15c.
(65) *Official Proceedings*, New York Railroad Club, Brooklyn, N. Y., 25c.
(67) *Cement and Engineering News*, Chicago, Ill., 25c.
(69) *Eisenbau*, Leipzig, Germany.
(71) *Journal*, Iron and Steel Inst., London, England.
(71*a*) *Carnegie Scholarship Memoirs*, Iron and Steel Inst., London, England.
(72) *American Machinist*, New York City, 25c.
(73) *Electrician*, London, England, 1s.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(77) *Journal*, Inst. Elec. Engrs., London, England, 5s.
(78) *Beton und Eisen*, Vienna, Austria.
(80) *Tonindustrie Zeitung*, Berlin, Germany.
(83) *Gas Age-Record*, New York City, 25c.
(85) *Proceedings*, Am. Ry. Eng. Assoc., Chicago, Ill.
(86) *Engineering and Contracting*, Chicago, Ill., 20c.

(87) *Railway Maintenance Engineer,* Chicago, Ill., 20c.
(88) *Bulletin* of the International Ry. Congress Assoc., Brussels, Belgium.
(89) *Proceedings,* Am. Soc. for Testing Materials, Philadelphia, Pa., $5.
(90) *Transactions,* Inst. of Naval Archts., London, England.
(91) *Transactions,* Soc. of Naval Archts. and Marine Engrs., New York City.
(92) *Bulletin,* Soc. d'Encouragement pour l'Industrie Nationale, Paris, France.
(96) *Canadian Engineer,* Toronto, Ont., Canada, 10c.
(98) *Journal,* Engrs. Soc. of Pa., Harrisburg, Pa., 30c.
(99) *Proceedings,* Am. Soc. of Municipal Improvements, New York City, $2.
(100) *Military Engineer:* Journal of the Society of American Military Engineers, Washington, D. C., 75c.
(103) *Mining and Scientific Press,* San Francisco, Cal., 15c.
(105) *Chemical and Metallurigical Engineering,* New York City, 25c.
(106) *Transactions,* Inst. of Min. Engrs., London, England, 6s.
(107) *Schweizerische Bauzeitung,* Zürich, Switzerland.
(109) *Journal,* Boston Soc. C. E., Boston, Mass., 50c.
(111) *Journal of Electricity and Western Industry,* San Francisco, Cal., 25c.
(113) *Proceedings,* Am. Wood Preservers' Assoc., Baltimore, Md.
(114) *Journal,* Institution of Municipal and County Engineers, London, England, 1s. 6d.
(115) *Journal,* Engrs. Club of St. Louis, St. Louis, Mo., 50c.
(116) *Blast Furnace and Steel Plant,* Pittsburgh, Pa., 15c.
(117) *Engineering World,* Chicago, Ill., 20c.
(118) *Times Trade Supplement,* London, England, 2d.
(119) *Landscape Architecture,* Harrisburg, Pa., 75c.
(120) *Automotive Industries,* New York City, 35c.
(121) *Proceedings,* Am. Concrete Inst., Detroit, Mich.
(122) *The Dock and Harbour Authority,* London, England, 1s. 6d.
(123) *Mining and Metallurgy,* New York City, $1.

LIST OF ARTICLES

Bridges.

Baltimore & Ohio Completes Large Bridge Project.* Philip G. Lang, Jr. (15) Dec. 3.
Nashville Concrete Bridges Show Serious Deterioration.* (13) Dec. 8.
Suldbach Tests: A Swiss Study of Bridge Action.* (13) Dec. 15.
Rebuilding of Incline Railway Trestle.* E. H. Darling. (96) Dec. 15.
Remplacement d'une des Voutes du Pont de Meulan par une Travée Metallique.* (Replacing one of the Arches of the Meulan Bridge by a Metallic Girder.) M. Reseau. (43) July–Aug.
Pont Suspendu Rigide sur Cables Ossature Rigide en Métal ou en Béton Armé.* (Rigid Bridge Suspended on Cables. Rigid Metallic Scaffold of Metal or Reinforced Concrete.) A. Vierendeel. (30) Oct.
Verstärkung der Gewölbe von Eisenbahnbrücken.* (Strengthening the Arches of Railroad Bridges.) Edgar Schmidt. (40) Jan. 26.
Regelquerschnitte für Strassenbrücken.* (Standard Sections for Street Bridges.) Mar. 23.

Electrical.

Wireless Telegraphy.* Alan A. Campbell Swinton. (29) Nov. 25.
World Communication.* Alfred N. Goldsmith. (42) Dec.
A Vacuum-Tube Alternating-Current Potentiometer.* E. C. Wente. (42) Dec.
Simple Equations for the Lamp Performance.* H. E. Eisenmenger. (42) Dec.
Shunting Characteristics of the Relay in an A.-C. Track Circuit Employed in Railroad Signaling.* C. F. Estwick. (42) Dec.
Calumet Station of the Commonwealth Edison Co.* A. D. Bailey. (4) Dec.
Transmission Characteristics of the Submarine Cable.* John R. Carson and J. J. Gilbert. (3) Dec.
The Path of a Small Permeable Body in a Magnetic Field.* W. Cramp. (26) Dec. 2.
A Research on Insulating Oils.* E. B. Wedmore. (73) Dec. 2.
First 220,000-Volt Station Completed.* (27) Dec. 3.
Tests on Insulating Varnish.* W. S. Flight. (26) Dec. 9.
The Alexanderson System for Long-Distance Radio Communication.* (From *General Electric Review.*) (73) Dec. 9.
Wave Length Relations for Progressive Antennae Generation.* A. Press. (73) Dec. 9.
Longer Spans Proposed for Rural Lines.* (27) Dec. 10.
Canadian Automatic Converter Sub-Station.* (12) Dec. 12.
Locating Faults in Direct-Current Armatures—Effects of Grounds. B. A. Briggs. (64) Dec. 13.
Station Electrical Layout for Supplying Local and Regional Service.* (27) Dec. 24.
How to Find Voltage-Drop in Electric Circuits.* Edgar P. Slack. (64) Dec. 27.
The Radio Central.* Austin C. Lescarboura. (46) Jan. 1922.
L'Emploi de L'Aluminium en Electricité. (The Use of Aluminum in Electricity.) E. Dusaugey. (92) July–Aug.–Sept.
L'Ecoute Sous-Marine et Quelquesuns de ses Progrès Récents.* (The Sub-Marine Listening Device and Some of the Progress It Has Made.) (33) Serial beginning Oct. 29.
L'Equipement Electrique des Ecluses du Canal du Rhin à Herne (Westphalie).* (The Electrical Equipment on the Locks of the Canal from the Rhine to Herne (Westphalie).) G. Mesnard. (33) Nov. 12.
Konstanthaltung der Umdrehungszahl von Elektromotoren zum Antrieb von Hochfrequenzmaschinen.* (Maintaining Constant the Number of Revolutions of Electric Motors for Driving High Frequency Machines.) W. Dornig. (41) Jan. 6.

* Illustrated.

Electrical—(Continued).

Einfaches Verfahren zur Trennung der Verluste bei Induktionsmotoren mit Schleifringanker.* (Simple Method for the Separation of Losses in Induction Motors with Slip Ring Rotors.) Rudolf Richter. (41) Jan. 6.
Technische Probleme der elektrischen Grosswirtschaft.* (Technical Problems of Electrical Large Scale Operations.) J. Biermanns. (41) Serial beginning Jan. 13.
Verfahren zur Bestimmung von Wärmeabgabekoeffizienten.* (Method for the Determination of the Coefficients of Thermal Radiation.) K. Lubowsky. (41) Jan. 27.
Zur Berechnung von Spannungsabfällen in Drehstrom-Freileitungen.* (On the calculation of the Voltage Drop in Overhead Lines with Multi-Phase Current.) G. Huldschiner. (41) Jan. 27.
Die Feldverteilung in elektrischen Hochspannungskabeln.* (Distribution of the Field in High Tension Electric Cables.) K. W. Wagner. (41) Feb. 3.
Elektrizitätswirtschaft in Chile.* (Electrical Development in Chile.) W. Musswitz. (41) Feb. 10.
Anwendung der Pintsch-Glimmlampe in der Schaltungstechnik.* (Use of the Pintsch Glow Lamp in the Technics of Connections.) Fritz Schröter. (41) Feb. 10.
Durchhang schwerer Isolatorketten an Hochspannungsleitungen.* (Sag of Heavy Insulating Chains in High Tension Lines.) Hch. Schenkel. (41) Feb. 17.

Marine.

Repairing the Concrete Dry Dock at South Chicago.* John V. Schaefer. (117) Dec.
Maag Gearing.* L. J. Le Mesurier. (Paper read before North-East Coast Inst. of Engrs. and Shipbuilders.) (11) Dec. 9.
Protection of Merchant Ships Against Submarines.* E. H. T. D'Eyncourt. (Paper read before North-East Coast Inst. of Engrs. and Shipbuilders.) (11) Dec. 9.

Mechanical.

Municipal Steam Heating System at Cleveland, Ohio.* H. W. Kaiser. (59) Nov.
Power Factor Correction and Its Relation to Plant Operation.* P. T. Vanderwaart. (2) Nov.
The Carbonization of Coal at Low Temperature.* John Roberts. (106) Nov.
British Concrete Machinery.* (12) Nov. 18.
The Fracture of Wire in Steel Ropes.* E. M. Horsburgh. (Paper read before British Assoc.) (11) Nov. 18.
Boiler-House Management.* David Brownlie. (Abstract of paper read before South Wales Inst. of Engrs.) (22) Serial beginning Nov. 18.
The Utility of Benzole for Transport Purposes. E. de Normanville. (114) Nov. 19.
The Reduction of Atmospheric Pollution Resulting from the Use of Gaseous Fuels.* J. S. Owens. (114) Nov. 19.
Simplified Approximations of Critical Speeds.* G. Arrowsmith. (11) Nov. 25.
Utilizing Flue Gases to Preheat Air to Furnace—Consideration of Some of the Problems Involved.* E. R. Welles and C. T. Mitchell. (64) Nov. 29.
Solving Refrigerating Problems by the Total Heat Diagram.* (64) Nov. 29.
Burning Anthracite Mine Waste Efficiently.* O. M. Rau. (64) Nov. 29.
Boiler and Furnace Economy. D. S. Jacobus. (55) Dec.
On the Art of Milling.* John Aircy and Carl J. Oxford. (55) Dec.
Heat Balance in Steam Power Plants. (55) Dec.
Material Handling an Important Factor in the Elimination of Industrial Waste.* H. V. Coes. (55) Dec.
Code on Definitions and Values. (Committee on Power Test Codes, Am. Soc. Mech. Engrs.) (55) Dec.
New Type of Bridge Crane for Handling Sand and Gravel.* W. A. Scott. (117) Dec.
Principles of Metallography as Applied to the Industry of Welding.* W. H. Ludington. (5) Dec.
Application of Pulverized Coal to Boilers. J. W. Fuller. (123) Dec.
Sound Steel in Rail Manufacture. Cecil J. Allen. (21) Dec.
Devices for Speeding Low-Temperature Carbonization and Procuring a Dense and Non-Friable Product.* A. Thau. (45) Dec. 1.
Present Status of Coal Carbonization at Low Temperature. Joseph D. Davis. (Abstract of paper read before Am. Gas Assoc.) (57) Dec. 2.
Pressure Gas for Industrial Furnaces.* F. J. Evans. (83) Dec. 3.
The Hartford Electric Light Company's South Meadow Station.* (64) Dec. 6.
Plunger of Low-Temperature Carbonizing Retort Expels Product as a Bar, a Knife Slicing Off Briquets.* A. Thau. (45) Dec. 8.
Double Helical or Herringbone Gears.* Howard H. Talbot. (20) Serial beginning Dec. 8.
The Exponential Method in the Analysis of the Balance of Reciprocating Masses.* P. Cormack. (11) Dec. 9.
Beehive Coke Ovens with Central Generator. H. Kleinholz. (24) Dec. 10.
Determination of Hydrogen Sulphide in Illuminating Gas. C. W. Jordan and W. H. Fulweiler. (Paper read before Am. Gas Assoc.) (24) Dec. 10.
Preheating Air for Gas Furnaces.* O. Lellep. (83) Dec. 10.
Largest Impulse Turbine Units in Carbou Station.* W. M. White. (64) Dec. 13.
Sawdust Burned with Aid of Steam Jets.* (64) Dec. 13.
The Augsburg Ten-Cylinder Four-Stroke Cycle U-Boat Diesel Engine.* John L. Bogert. (64) Dec. 13.
The Volume of Air Required in Air Drying.* C. T. Mitchell. (105) Dec. 14.
Gear Tooth, Shape and Its Relation to Standardization.* E. W. Miller. (From paper read before Am. Gear Manufacturer's Assoc.) (120) Dec. 15.
Buck Run Coal Co. Methods of Preparing and Storing Coal.* Dever C. Ashmead. (45) Dec. 15.

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* Illustrated.

Mechanical—(Continued).

Piette By-Product Coke Ovens at St. Louis.* (20) Dec. 15.
Refrigeration and Ice Making as a Central Station Load.* Carl K. Chapin. (111) Dec. 15.
Caribou Power Plant Has World's Largest Impulse Wheel.* W. M. White. (111) Dec. 15.
Notes on Motor Car Gear-Boxes.* H. F. L. Orcutt. (Paper read before Inst. Automobile Engrs.) (11) Serial beginning Dec. 16.
By-Product Coke Ovens in the Gas Industry.* B. W. Winship. (24) Dec. 17.
Purification of Towns Gas. (118) Dec. 17.
Destructive Distillation of Mixtures of Oil and Coal.* Joseph D. Davis and others. (105) Dec. 21.
Considerations in Changing a Quarry from Hand to Steam Shovel Method. Irving Warner. (From paper read before National Lime Assoc.) (86) Dec. 21.
Reversing Facilities for Use with or on Rail Cars.* Donald A. Hampson. (120) Dec. 22.
Springdale Mine Furnishes Fuel to West Penn Power Co. Plant, Cleaning Every Car of Coal Before Weighing.* D. J. Baker. (45) Dec. 22.
Apparatus for the Continuous Analysis of Gas.* Ismar Ginsberg. (Translation from *Das Gas und Wasserfach.*) (24) Dec. 24.
Working Temperatures and Pressures in the Refrigeration Plant.* W. H. Motz. (64) Dec. 27.
Distilled Water for Boiler Feed at River Rouge Plant. (64) Dec. 27.
Intake, Compression, Power and Exhaust. (46) Jan. 1922.
Compte-Rendu de L'Exposition des Appareils de Controle de la Chauffe.* (Report on the Exposition of Apparatus for the Control of Heating.) M. P. Frion. (32) Jan.–Mar.
Etat Actuel de la Carburation au Pétrole Lampant.* (Actual Status of Kerosene Carburation.) M. Drosne. (32) Serial beginning Jan.–Mar.
Le Chauffage au Charbon Pulvérisé. (Heating with Pulverized Coal.) Paul Frion (32) Apr.–June.
Introduction à l'Etude de la Carburation Pyrodynamique du Moteur à Explosions.* (Introduction to the Study of the Pyrodynamical Carburation of the Explosion Engine.) M. Carbonaro. (32) Apr.–June.
La Carburation par le Pétrole Lampant et L'Action de Paroi.* (Carburation by Kerosene and the Action of the Wall.) M. G. Lumet. (32) Apr.–June.
L'Emploi des Pétroles Lampants dans les Moteurs d'Automobiles.* (The Use of Kerosene in Automobile Engines.) M. A. Grebel. (32) Apr.–June.
Les Carburateurs a Pétrole.* (Petrol Carburetors.) M. A. Mariage. (32) Apr.–June.
Observations Faites au Sujet du Mémoire de M. Drosne sur l'Etat Actuel de la Carburation au Pétrole Lampant.* (Remarks on the Subject of the Memoire by Mr. Drosne on the Actual Status of Kerosene Carburation.) M. Guiselin. (32) Apr.–June.
Les Métaux Légers dans la Construction mécanique et, en Particulier, dans l'Industrie Automobile.* (Light Metals in Mechanical Constructions and Especially in the Automobile Industry.) R. de Fleury. (92) July–Aug.–Sept.
Transmission Automatiquement Progressive, Systéme Rémondy. (Progressive Automatic Transmission, Rémondy System.) P. Calfas. (33) Nov. 5.
Appareil et Machines pour le Tracé, le Taillage et la Rectification de tous Engrenages à Développante Basés sur de Nouveaux Principes.* (Apparatus and Machines for Tracing, Cutting and the Rectifying of all Gears with Teeth Based on New Principles.) (33) Nov. 12.
La Technique Actuelle des Centrales a Vapeur. Rapport de la Commission d'Utilisation des Combustibles. (Actual Practise in Central Steam Stations. Report of the Commission on the Utilization of Fuel.) (33) Nov. 19.
L'Accumulateur de Vapeur Ruths.* (Ruths Steam Accumulator.) E. G. Constam-Gull. (33) Nov. 26.
Die Dynamik des Kreisels und ihre technische Anwendung.* (The Dynamics of the Top and Its Technical Application.) Wilhelm Hort. (40) Serial beginning Feb. 2.
Kohlenstaubfeuerungen für Elektrizitätswerke.* (Coal Dust Firing for Electric Power Plants.) Friedrich Münzinger. (41) Feb. 3.
Verwendung von Torf in den Kesselfeuerungen auf Baggern und Dampfprahmen des Hafenbauamts in Pillau.* (The Use of Peat in Boiler Furnaces on Excavators and Steam Barges in the Harbor Construction Plant at Pillau.) Becker. (40) Feb. 9.
Die Torfstreu als Wärmeschutz. (Peat Dust as a Heat Insulator.) Noack. (40) Mar. 12.
Heizung, Warmwasserbereitung und Trocknung durch Abfallwärme.* (Heating, Warming Water, and Drying with Waste Heat.) F. Frenckel. (48) Nov. 5.
Der menschliche Segelflug.* (Human Sail Flight (Aeroplanes).) R. Katzmayr. (53) Nov. 11.
Erfahrungen an Eindampfanlagen mit Wärmepumpe.* (Experiences in Evaporating Plants with a Heat Pump.) E. Wirth. (48) Nov. 12.
Eine Umwälzung im Schiffskesselbau.* (A Revolution in Marine Boiler Construction.) K. Meerbach. (50) Nov. 17.
Milchwirtschaftliche Maschinen, insbesondere zur Butterbereitung.* (Milk Machines, Especially in the Manufacture of Butter. Alb. Fischer. (48) Nov. 19.
Abwärme-Verwertung.* (Utilization of Waste Heat.) M. Hottinger. (107) Serial beginning Nov. 19.

Metallurgical.

Continuous Rolling-Mills.* John W. Sheperdson. (58) May.
The Friction Coefficient of Minerals.* Stanley Nettleton. (106) Nov.
On the Theory of the Hardening of Metals. Kotoro Honda. (105) Nov. 30.
Commercial Production of Electrolytic Iron.* C. P. Perin and Donald Belcher. (123) Dec.
Effect of Sulfur and Oxides in Ordnance Steel. William J. Priestley. (123) Dec.
Strain Lines in Low Carbon Steel.* (20) Dec. 1.

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Chromium Steels and Iron.* Leslie Aitchison. (Paper read before Inst. of Automobile Engrs.) (12) Serial beginning Dec. 2.
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Fatigue of Metals Under Repeated Stress.* (105) Dec. 21.
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Ball-Milling and Flotation at Catemu, Chile.* F. Benitez. (103) Serial beginning Dec. 24.
The Electrolytically Produced Calcium-Barium-Lead Alloys Comprising Frary Metal.* William A. Cowan and others. (Paper read before Am. Electrochemical Soc.) (105) Dec. 28.
Hardness of High-Speed Steel.* A. H. D'Arcambal. (105) Dec. 28.
L'Emploi de L'Aluminium dans les Industries Chimiques et les Procédés de Fabrication du Matériel en Aluminium (Soudures, Recouvrements, Emaillage, Métallisation).* (The Use of Aluminum in the Chemical Industries and Processes for the Manufacture of Aluminum Objects (Welds, Coatings, Enamelling and Metallisation.) R. Guérin. (92) July–Aug.–Sept.
L'Aluminium, sa Fabrication, ses Propriétés, ses Alliages, leur Emplois.* (Aluminum, Its Manufacture, Its Properties, Its Alloys, Their Uses.) M. Léon Guillet. (92) July–Aug.–Sept.
Les Alliages Légers et leur Emploi en Aéronautique.* (Light Alloys and Their Use in Aeronautics.) C. Grard. (92) July–Aug.–Sept.
Les Emplois de l'Aluminium dans l'Appareillage Electrique.* (The Uses of Aluminum in Electric Apparatus.) M. C. Zetter. (92) July–Aug.–Sept.
Les Aciéries de Rombas, pres Metz (Moselle).* (The Rombas Steelworks near Metz (Moselle).) Ch. Dantin. (33) Nov. 5.
La Fabrication des Poutrelles à Larges Ailes du Type Grey, aux Usines de Differdange (Luxembourg).* (The Manufacture of Wide Flange Beams of the Grey Type at the Differdange Shops (Luxembourg).) J. Audegé. (33) Nov. 19.
Temperaturmessungen an Giesspfannen für Eisen- und Stahlgiessereien.* (Temperature Measurements in Casting Ladles for Iron and Steel Foundries.) L. Treuheit. (50) Serial beginning Oct. 27.
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Die fortlaufende wärmetechnische Ueberwachung der Gasfeuerungen in Hüttenbetrieben.* (Continuous Expert Supervision Over the Heat in Gas Firing in Metallurgical Operations.) Hermann Wolf. (50) Nov. 10.
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The Electrolytic Oxidation of H. C. L. to Perchloric Acid.* H. M. Goodwin and E. C. Walker, 3d. (Paper read before Am. Electrochemical Soc.) (105) Dec. 14.
La Fabrication Electrolytique de l'Oxygène et de l'Hydrogène, par le Procédé Zorzi.* (The Electrolytic Production of Oxygen and Hydrogen. (33) Nov. 12.
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La Mécanique Classique et la Théorie de la Relativité. (Classical Mechanics and the Theory of Relativity.) Paul Painlevé. (33) Nov. 12.
Le Principe de la Relativité et les Théories d'Einstein. (The Relativity Principle and Einstein's Theories.) H. Vigneron. (33) Nov. 12.

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Procédés Récents d'Exécution des Travaux Publics Train de Travaux pour l'Exécution des Travaux d'Etablissement des Lignes Aériennes de Distribution d'Energie Electrique.* (Recent Processes for Carrying Out Public Works. Work Train for the Execution of the Works and the Establishment of Overhead Lines for the Distribution of Electrical Energy.) M. Nabonne. (43) July–Aug.
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Le Nouveau Régime des Chemins de Fer Francais. Modification des Tarifs à Prévoir.* (The New French Railway Administration. To Provide for a Modification of the Rates.) G. Peyrabon. (33) Serial beginning Nov. 26.

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Stosswikungen unrunder Bremsräder auf den Eisenbahnoberbau.* (Action of Shocks of Uneven Brake Wheels on the Superstructure of Railroads.) Saller. (40) Serial beginning Mar. 5.
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Der Rhein von Basel bis Konstanz als Grosschiffahrtstrasse und Kraftquelle.* (The Rhine from Basel to Konstanz as a Navigable Stream and Source of Power.) Theodor Lutz. (40) Jan. 8.
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AMERICAN SOCIETY OF CIVIL ENGINEERS

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PROCEEDINGS

HIGHWAY ENGINEERING

ROADS AND PAVEMENTS

A SUBJECT CATALOG OF THE BOOKS AND PAMPHLETS IN THE ENGINEERING SOCIETIES LIBRARY,

DECEMBER, 1921.

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ROADS AND PAVEMENTS

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NOTE: The numbers which follow the titles are reference numbers for use in the Library, indicating the location of the book and its identification number.

Bibliography 625.7 (016)

Ballen, Dorothy. Bibliography of road making and roads in the United Kingdom. Lond., 1914. 016.6257 B21
An exhaustive bibliography within its field. The place entries are limited to Great Britain, but references covering construction and repair include practice in all countries. "A revised and considerably enlarged edition of the bibliography compiled by Mr. and Mrs. Webb in 1906".

Blanchard, Arthur Horace, 1877- ed. American highway engineers' handbook, editor-in-chief: Arthur H. Blanchard; associate editors: Charles J. Bennett, Harold S. Boardman and others. N. Y., 1919. **625.7 A02b**
Bibliography at end of each section.

Brooks, Robert Clarkson, *comp.* Bibliography of municipal problems and city conditions. Ed. 2, rev. and enl. N. Y., 1901. 016.352 B79
Pavements and paving, p. 218-221.
Streets, street building, cleaning, etc., p. 257-258.

Frost, Harwood. The art of roadmaking...... with an extensive bibliography and a descriptive list of reliable current books and pamphlets on these subjects. N. Y., 1910. **625.7 F92**

Genzmer, Ewald. Die städtischen strassen; mit einer einleitung: Der städtische tibau im allgemeinen. 1897-1900. **625.7 G28**
Litteratur: v. 1, p. 136-140; v. 2, p. 301-311.

Good roads year book. 1912-16. Wash. [American highway association], 1912-16. **625.7 G59**
Contains bibliographies.

Highways green book. (1st, 1920). Amer. automobile assn., Wash., 1920. **625.7 H53**
Contains bibliographies.

Jenkins, Rhys. Power locomotion on the highway; a guide to the literature relating to velocipedes by steam and other mechanical power. Lond., 1896. **016.62114 J41**

Laissle, Friedrich von. Strassenbau einschliesslich der strassenbahnen. 1912. (Handbuch der Ingenieurwissenschaften. 1. t. 4. bd.) *Litteratur:* p. 192-203. **620 H192=1. t. bd. 4**

Munro, William Bennett. A bibliography of municipal government in the United States. 1915. **016.352 M92**
Streets and sidewalks p. 141-150.
Street cleaning, snow removal and dust prevention, p. 281-287.

New York (City) Public Library. Check list of works relating to the streets of the city of New York in the New York public library, 1901. (*Bulletin* of the New York public library, 1901, v. 5, p. 151-159). **M010.5 N46 v. 5**

Pittsburgh. Carnegie library. Road dust prevention [a bibliography]. 1916. **017.1 P68b v. 21**
(Monthly bulletin of the Carnegie library of Pittsburgh, v. 21, 1916, p. 148-183.)

U. S. Congress. Joint committee on federal aid in the construction of post roads. Federal aid to good roads. 1915. **625.709 Un3**
Bibliography ...... by H. H. B. Meyers, chief bibliographer [Library of Congress]: p. 293,313.

Washington (State) State library, Olympia. Select list of references on roads. Comp. by Washington state library for the intra-high school debate, 1912-1913. Olympia, Wash., 1912. **016.6257 W27**

Wheeler, Harold Leslie. List of references on the construction and maintenance of rural roads; revised to Nov., 1919. **625.709 H24**
(In Harris, Elmo Golightly. Road problems in the Ozarks. 1919, p. 61-67.)

*This list is a reprint of the subject entries in the card catalog of the Library on December 31st, 1921. The Library is in process of recataloging and until this work is finished no one subject can be considered complete. For example, when the books on machinery are recataloged many analytical references may be added to the machinery group of road engineering.
Neither the author catalog nor the subject index to this group has been included here. They may be consulted at the Library.

The Library has the following searches, or bibliographies, covering Roads and Pavements. Copies of these may be secured at the prices listed. New searches will be compiled upon request.

ROADS

No.	Price.	No. of Ref.	
158	$0.25	5	Methods of treating street intersections, that give a basis for figuring the elevations of the different parts, when the elevation of the intersection of the center lines is known and the longitudinal slopes of the streets are fixed (1905).
237	0.40	8	Use of crude petroleum on roads (1906).
265	8.75	175	Street cleaning (covers collection of city refuse, but not disposal) (1907).
356	3.45	69	Repair and maintenance of Telford and macadam roads (1908).
541	1.30	26	Actual tests of the tractive force required to move a given weight on roads and level railroads (1911).
598	0.25	5	Approximate area of streets and of building spaces in large cities (1911).
612	2.00	37	Impurity of street washings (1912).
617	1.05	21	Foundations for highways in soft mud (1912).
633	0.80	9	Peekskill or Roa Hook gravel (1912).
639	5.40	108	Surfacing of highway bridge floors (1912).
666	1.95	39	Effect of motor traffic on roads (1913).
685	2.70	16	Road maintenance; methods of organization and cost (1913).
686	0.40	4	Street signs in concrete sidewalks (1913).
692 } 692a }	21.90 } 4.20 }	291 } 84 }	Use of different kinds of rock in the construction of wearing surfaces of roads and pavements and for railroad ballast (1913).
729	2.40	48	Municipal or State highway engineering organization (1913).
852	5.20	106	Financing of highway improvements (1915).
921	2.85	20	Amount of friction and pressure of wheels on roads of different kinds of soil (1916).
981	3.50	5	Asphalt over coal-tar surfaces in road work (1916).
986	1.80	7	How to apportion costs of city improvements, especially street openings (1916).
1000	0.75	12	Highway legislation. methods of taxation and maintenance (1916).
1084	2.10	42	Maintenance of highways (1917).
2330	6.65	43	Ballast and ballasting and tests of ballasts (1918).
2686	12.60	28	Highway cost accounting (1919).
3049	20.25	35	Construction of roads and bridges through tidal marshes (1920).
3147	12.50	30	General standard specifications for highways and highway bridge construction in the United States (1920).
3174	16.20	53	Current contract prices. Heavy construction work (1920).
3231	21.60	36	Cost of engineering on public works, especially on public road work (1920).
3408	61.00	159	Tractive resistance of roads and collateral subjects (1921).
46	0.60	12	Statistics of macadam and other pavements (1901).
267	1.95	39	Statistics of street paving in cities other than New York, 1896 to 1907 (1907).
383 } 383a }	1.10 } 1.35 }	22 } 27 }	Different methods of making assessments for brick pavements or other street improvements (1908) (1911).
599	5.10	102	Highway and permanent pavement design (1912).
776	4.00	83	Bituminous materials, concrete and reinforced concrete as city paving materials (1914).
789	1.90	18	Settlement of streets and buildings due to the construction of tunnels in America (1914).
843	2.00	29	Construction of street car tracks in paved streets (1915).

PAVEMENTS

(Special kinds)

No.	Price.	No. of Ref.	
92	1.00	20	Paving brick tests (1904).
220 } 220a }	1.00 } 2.10 }	20 } 42 }	Use of Tee rails by street surface railroads, particularly in connection with brick paving (1906) (1912).
244 } 244a }	5.80	116	Wood pavements (1908).
248	0.40	8	Construction of street railway tracks, 1905-1906, in streets paved with vitrified brick (1907).
251	1.00	20	Use of asphalt blocks and their comparison with brick paving (1907).
317 } 317a }	3.90 } 14.30 }	78 } 279 }	Use of tar, bitumen, oil, cement, etc., on macadam roads before and after construction (1907) (1916).
418	0.90	18	Specifications for macadam roads (1909).
472	0.80	16	Action of illuminating gas on asphalt pavements (1910).
572	1.60	32	Durability of concrete pavements (1911).
573a	0.40	8	Concrete products (1911).
669	3.05	51	Construction, maintenance and oiling of macadam roads (1913).
764	42.80	856	Reinforced concrete (1914).
816 } 816a }	1.10 } 1.95 }	15 } 42 }	Warren brothers bitulithic pavement (1914).
840	2.65	53	Stone block pavement (1915).
842	4.00	80	Wooden block pavements (1915).
2077	3.15	7	Concrete roads, relation between strength of concrete and wear of surface (1918).
2385	5.00	34	Reinforced concrete roads (1918).
2808	4.80	10	Specifications for creosoted wood block paving (1919).
2962	32.40	144	European method of preparation of rock asphalt and its use in roads and pavements (1920).
2988	19.00	36	Concrete foundations for bituminous pavements; bond between concrete and bituminous materails or between old and new concrete (1920).

Roads 625.7 General

Agg, Tansy Radford. American rural highway. N. Y., 1920. **625.7 Ag38**

Agg, Tansy Radford. Construction of roads and pavements. N. Y., 1916. **625.7 Ag38c**

——— ————— Ed. 2, rev. and enl. N. Y., 1920. **625.7 Ag38c2**
Glossary: p. 408-414.

Ahlburg. Der strassenbau mit einschluss der construction der strassenbrucken. Braunschweig, 1870. **625.7 Ah4**

Aitken, Thomas. Road making and maintenance: practical treatise for engineers, surveyors, and others; with an historical sketch of ancient and modern practice. Lond., 1900. **625.7 Ai9**

American institute of consulting engineers. Abstract of discussion on the subject of the principles and broad economics of highway design and construction. N. Y., 1920. **625.7 Am3**

Baker, Ira Osborn. A treatise on roads and pavements. 3d ed., rewritten and enl. N. Y., 1918. **625.7 B17.3**
Library also has Ed. 1, 1903 and Ed. 2, 1913.

Baskerville, Charles. Municipal chemistry. 1911. **614 B29**
Contains chapters on Streets and their construction, by A. S. Cushman; Modern road construction; and Street sanitation, by W. H. Edwards; Methods of street cleaning and waste disposal of the city of New York, by E. D. Very.

Blanchard, Arthur Horace. Elements of highway engineering. N. Y., 1915. **625.7 B592E.**

Blanchard, Arthur Horace. Text-book on highway engineering by A. H. Blanchard and H. B. Drowne. N. Y., 1913. **625.7 B592T**

Boulnois, Henry Percy. Modern roads. Lond., 1919. **625.7 B66**

Boulnois, Henry Percy, *comp.* Practical road engineering for the new traffic requirements. Comp. from the special "roads" issues of the Surveyor and municipal and county engineer. Lond., 1910. **625.7 B66p**

Byrne, Austin Thomas. Treatise on highway construction....the location, construction, or maintenance of roads, streets and pavements. Ed. 5, rev. and enl. N. Y., 1908. **625.7 B99a**
Authors and publication referred to: pref. 5-8.

——— ————— Ed 4, rev. and enl. N. Y., 1900. **625.7 B99**
Library also has the following editions:
Ed. 3, rev. and enl., 1896.
Ed. 2, rev. and enl., 1893.
1892.

Chatburn, George Richard, 1863—Highway engineering, rural roads and pavements, N. Y., 1921. **625.7 C39**
Bibliography: p. iv-vi.

Chicago. Commission on city expenditures. Preliminary report on the McGovern street repair contract of 1908. Chic., 1910. **625.7 C43**
This is the progress report of Samuel Whinery.

Clark, Daniel Kinnear. The construction of roads and streets. Lond., 1877. **625.7 C54**
pt. 1. The art of constructing common roads, by Henry Law; rev. and condensed by D. K. Clark.
pt. 2. Recent practice in the construction of roads and streets, including pavements of stone, wood, and asphalte, by D. K. Clark.

Coane, John Montgomery. Australasian roads; a treatise, practical and scientific, on the location, design, construction and maintenance of roads and pavements. Ed. 2, rev. and enl. Melbourne, 1915. **625.7 C63a**

Corner, Charles. Country roads. 1895. **625.7 N51**
Read before the Texas academy of science, June, 1895.

Costa Rica. Dirección general de obras públicas. Circulares numeros 49 y numero 59 y reglas y principios generales que deben atenderse en la composición de los caminos y carreteras nacionales, apertura de callejones y veredas de la república. San José, 1906. **625.7 C882**

[Du Pont de Nemours, E. I., powder company]. Road construction and maintenance. [Wilmington, Del., 1915.] **625.7 D928R**

Engineering record, Building record and the Sanitary Engineer. Road construction and maintenance: prize essays. N. Y., 1892. **625.7 En3**
Contents: Road construction and maintenance; by S. C. Thompson; Road construction, by I. F. Pope; Construction of roads, by J. P. Pritchard.

Foote, Charles Elmer. Practical road building. Phila., 1917. **625.7 F74**

Frost, Harwood. The art of roadmaking, treating of the various problems and operations in the construction and maintenance of roads, streets, and pavements, written in non-technical language. N. Y., 1910. **625.7 F92**

Gallatin, Albert. Report of the Secretary of the treasury on the subject of public roads and canals; made in pursuance of a resolution of Senate, of March 2d, 1807. **626 Se1**

Gearhart, Walter Scott. Highway improvement; construction and maintenance of earth, sand-clay and oiled earth roads, and culverts. Manhattan, 1910. (Kansas state agricultural college. Agricultural education. v. 3, No. 6.) **625.7 G26v.3**

Genzmer, Ewald. Die städtischen strassen; mit einer einleitung: Der städtische tiefbau im allgemeinen, von Eduard Schmitt. Stut., 1897-1900. **625.7 G28**
Litteratur: v. 1, p. 136-140; v. 2, p. 301-311.

Gillespie, William Mitchell. A manual of tthe principles and practice of road-making; comprising the location, construction, and improvement of roads (common, macadam, paved, plank, etc.) and rail-roads. Ed. 10, enl. by Cady Staley. N. Y., 1871. **625.7 G41a**

——— ——————— Ed. 9, enl. N. Y., 1860. **625.7 G41**
Library also has the follows editions:
Ed. 2, enl. 1848.
Ed. 3, enl. 1849.

Gillette, Halbert Powers. Economics of road construction. Ed. 2, enl. N. Y., 1906. **625.7 G413E2**

——— ——————— N. Y., 1901. **625.7 G413E**

Gillmore, Quincy Adams. Practical treatise on roads, streets, and pavements. N. Y., 1876. **625.7 G417P**

——— same. Ed. 6. N. Y., 1888. **625.7 G417P2**

Good roads year book. 1912-16. Wash., 1912-16. **625.7 G59**
1912-15 have title: The Official good roads year book of the United States.
Contains Bibliographies.
Most of the vols. contain "State road legislation", Patents issued, and Directories of road contractors.

Hanson, Edward Smith. Concrete roads and pavements. Rev. ed. Chic., 1914. **625.8 H198c2**
Appendix on Specifications.

——— ——————— Chic., 1913. **625.8 H198c.**

Harger, Wilson Gardner. The location, grading and drainage of highways; a concise discussion of general principles. N. Y., 1921. **625.7 H22**

Herschel, Clemens. Prize essay on roads and road making. N. Y., 1877. **625.7 H43p**
Paper assigned the prize offered by the Massachusetts state board of agriculture for the best treatise on road making.

Herschel, Clemens. The science of road making; by Clemens Herschel....Construction and maintenance of roads; by Edward P. North. N. Y., 1894. **625.7 H43**

Highways green book, (1st, 1920). Wash., [1920]. **625.7 H53**
Contains bibliographies.
CONTENTS: Pt. 1. Information relating to road improvement under federal, state and local control. Pt. 2. Highway construction and maintenance. Pt. 3. Miscellaneous information and tables.

Hughes, Thomas. The practice of making and repairing roads; of constructing footpaths, fences, and drains; also, a method of comparing roads with reference to the power of draught required. Lond., 1838. **625.7 H87**

[Improvement of highways; a collection of pamphlets.] 1870-1918. **625.7 Im7**

International road congress, 2d. Brussels, 1910. Highway engineering, by Arthur H. Blanchard and Henry B. Drowne. N. Y., 1911. **625.7 In8**

International road congress, 3d. Lond., 1913. **625.7 A06313 v. 3**
Statistics of cost of construction and maintenance [of roads].
(Reports, 1st sec. v. 3).

Judson, William Pierson. City roads and pavements suited to cities of moderate size. 2d ed., rev. and enl. N. Y., 1902. **625.7 J92a**

——— ——————— Ed. 3, rev. N. Y., c1906. **625.7 J92a3**

Kaven, A. Von. Vorträge über ingenieur-wissenschaften an der Polytechnischen schule zu Aachen; einleitung zum wege- und eisenbahnbau und der wegebau. 2. aufl. Hannover. 1870. **625 K17**

Laissle, Friedrich von. Strassen bau einschl. der strassenbahnen. 4, verm. aufl. Leipzig, 1912. **620 H192 l.t.bd.4**
Vorarbeiten, erd-, grund-, strassen- und tunnelbau.
Handbuch der ingenieurwissenschaften. 1. t. 4. bd.
"Literatur": p. 192-203, 358-416, 557-571.
Library has: 1903, 3. aufl. 1912, 4. aufl.

Law, Henry. Rudiments of the art of constructing and repairing common roads; to which is prefixed A general survey of the principal metropolitan roads, by Samuel Hughes. Lond., 1850. **625.7 141**

——— ——————— Ed. 2, with additions. Lond., Weale, 1855. **625.7 L41a**

——— ——————— together with additional remarks on the maintenance of macadamised roads, by J. F. Burgoyne, Ed. 3, with additions. Lond., 1861-62. **625.7 L41a3**
This article by Henry Law forms the basis for a later work: Construction of roads and streets, by Henry Law and D. K. Clark.

League of American wheelmen. Improvement of highways. Buffalo, 1889. **625.7 L47**

Lefebvre, Georges. Voie publique. Paris, 1896. **625.7 L52**

[Love, Edward G] *comp.* Pavements and roads; their construction and maintenance. Reprinted from the Engineering and building record. N. Y., 1890. **625.8 L94**
CONTENTS: pt. I., Stone pavements. Wood pavements. Asphalt pavements. Brick pavements. Curbs, sidewalks and tramways. Street opening, maintenance. Notes.—pt. II, Roads: Construction and maintenance.—pt. III. Prize essays on road construction and maintenance, submitted in the competition instituted by the Engineering and building record. Report of Committee of award.

Lyman, Richard Roswell. The construction and maintenance of earth roads. Salt Lake City, 1910. **622 AO72u no. 3**

McAdam, John Loudon. Remarks on the present system of road making; with observations, deduced from practice and experience, with a view to a revision of the existing laws, and the introduction of improvement in the method of making, repairing, and preserving roads; and defending the road funds from misapplication. Carefully rev., and an appendix. Lond., 1827. **625.7 M11a9**

——— ——— Ed. 4, rev. and enl. Lond., Longman, 18. **625.7 M11a4**

Morrison, Charles Edward. Highway engineering. N. Y., 1908. **625.7 M83**

Municipal journal. Practical street construction; planning streets and designing and constructing the details of street surface, subsurface and supersurface structures, reprinted from Municipal journal, 1916; profusely illustrated with photographs, maps and diagrams. N. Y., 1916. **625.7 M92**

National free labor association.. Road making by convict labor. N. Y., 1913. (Ser. no. 1, bull. no. 1.) **331.51 N21**
A list of articles on convict road work, p. 48.

Nicholl, T. J. Improvement of prairie roads and streets. Chic., 1878-79. **625.7 N51**
From Civil engineers' club of the northwest. Proceedings. v. 4.

Oberschulte, Ludwig. Vorarbeiten für eisenbahnen und strassen. Bauleitung. 4. verm. aufl. Leipzig, 1904. **620 H192 l. t. bd. 1**
Vorarbeiten. erd,- grund-, strassen- und tunnelbau. l. t. des Handbuchs der ingenieurwissenschaften. l. bd.
CONTENTS: Vorwort.—Vorarbeiten für eisenbahnen und strassen.—Bauleitung.
Library has:
1880, Text, Atlas und Tafeln.
1898, 3, aufl.
1904, 4. aufl.

Page, Logan Waller. Roads, paths and bridges. N. Y., 1912. **625.7 P14**
"Authorities consulted": p. 257-259.

Parnell, Sir Henry Brooke. Treatise on roads; wherein the principles on which roads should be made are explained and illustrated by the plans, specifications and contracts made use of by Thomas Telford on the Holyhead road. Lond., 1833. **625.7 P24**

Pennsylvania. University. A move for better roads: essays on roadmaking and maintenance and road laws; with a synopsis of other contributions and a review, by Lewis M. Haupt, Phil., 1891. **625.7 P38**

Pope, Albert A. Memorial to Congress on the subject of a comprehensive exhibit of roads, their construction and maintenance, at the World's Columbian exposition. [Bost., 1892.] **625.7 P81**

Pope, Albert A. Memorial to Congress on the subject of a road department at Washington, D. C., and a comprehensive exhibit of roads, their construction and maintenance, at the World's Columbian exposition. [Bost., 1893.] **625.7 P81m**

Pope, Albert A. *comp.* Wagon roads as feeders to railways. Bost., 1892. **625.7 N51**

Roads and pavements; papers presented before the short course in highway engineering held at the University of Texas, 1919, under the auspices of the Department of engineering. Austin, Tex., [1919]. **625.7 R53**
CONTENTS.—Earth roads, by R. G. Tyler.—The preparation of road plans involving state or federal aid, by M. C. Welborn.—Drainage areas and culverts, by G. G. Wickline.—Preparation of specifications and contracts, by R. G. Tyler.—Road surfaces, by J. D. Fauntleroy.—Bituminated roads, by M. C. Welborn.—Penetration bituminous pavements, by R. G. Tyler.—Trap rock as the mineral aggregate in hard-surfaced roads and streets, by A. H. Muir and E. L. Dennis, jr.—Concrete construction, by J. Montgomery.

Roads and pavements. Austin, Tex., [1917]. **625.7 R53**
CONTENTS.—Concrete roads, by A. W. Bowles.—Asphalts and tars in surface treatments, by R. G. Tyler.—Penetration bituminous pavements, by R. G. Tyler.—A discussion of road materials, by J. P. Nash.
Bound with Roads and pavements, 1919.

Rockwell, Alfred Perkins. Roads and pavements in France. N. Y., 1896 [1895] **625.7 R59**

Roux, Onesime. Routes et chemins vicinaux. Paris, 1901. (Bibliothèque du conducteur de travaux publics) **625.7 R76**

Ryves, Reginald Arthur. The king's highway; the nature, purpose, and development of roads and road systems. Lond., [1908]. **625.7 R98**

Schuberg, Karl. Der waldwegbau und seine vorarbeiten. Berlin, 1873-75. **625.7 Sc78w**

Shaler, Nathaniel Southgate. American highways; a popular account of their conditions, and of the means by which they may be bettered. N. Y., 1896. **625.7 Sh1**
List of important works on highway construction: p. 292-293.

Spalding, Frederick Putnam. Text-book on roads and pavements. Ed. 4. rev. and enl. N. Y., 1912. **625.7 Sp1a4**

——— ——— Ed. 3, rev. and enl. N. Y., 1908. **625.7 Sp1a3**

——— ——— Ed. 1. N. Y., 1894. **625.7 Sp1**

Umpfenbach, Franz Anton. Theorie des neubaues, der herstellung und unterhaltung der kunststrassen. Berlin, 1830. **625.7 Um6**

U. S. Bureau of public roads. Modern road building and maintenance; principles and practice. Prepared for the use of engineers by A. P. Anderson. n. p. 1920? **625.7 un37**
CONTENTS: Planning.—Road materials.—Construction.—Maintenance and repair.—Use of explosives.

United States. Dept. of agriculture. Best roads for farms and farming districts, by Roy Stone; State highways in Massachusetts, by George A. Perkins; Improvement of public roads in North Carolina, by J. A. Holmes. Wash., 1895. **625.7 N51**

Reprinted from the Yearbook of the Department of agriculture for 1894.

U. S. Dept. of agriculture. Office of public roads. ...... Bulletin no. 1-48. Wash., 1894-1913. **625.709 Un3b**

No more published. Nos. 10, 14, 18, 22, 25, 39 wanting.

CONTENTS: no. 1. State laws relating to the management of roads, enacted in 1888-93. Comp. by Roy Stone. 1894.—no. 2. Proceedings of the Minnesota good roads convention ...... 1894. 1894.—no. 3. Improvement of the road system of Georgia. By O. H. Sheffield. 1894.—no. 4. Report on road-making materials in Arkansas. By J. C. Branner. 1894.—no. 5. Information regarding road materials and transportation rates in certain states west of the Mississippi River ...... 1894.—no. 6. Information regarding roads, road materials, and freight rates in certain states north of the Ohio River ...... 1894.—no. 7. Information regarding roads and road-making materials in certain eastern and southern states ...... 1894.—no. 8. Earth roads: hints on their construction and repair. Comp. by Roy Stone ...... 1894.—no. 9. State aid to road-building in New Jersey, by Edward Burrough ...... 1894.—no. 10. Proceedings of the National road conference ...... 1894. 1894.—no. 11. Proceedings of the Virginia good roads convention ...... 1894. 1895.—no. 12. Wide tires. Laws of certain states relating to their use and other pertinent information. Comp. by Roy Stone. 1895.—no. 13. Kentucky highways. History of the old and new systems. By M. H. Crump. 1895.—no. 14. Good roads. Extracts from messages of governors. Comp. by Roy Stone. 1895.—no. 15. Proceedings of the Good roads convention of Texas ...... 1895. 1895.—no. 16. Notes on the employment of convicts in connection with road building. Comp. by Roy Stone. 1895. Rev. ed., 1898.—no. 17. Historical and technical papers on road building in the United States. Comp. under the direction of Roy Stone. 1895.—no. 18. State laws relating to the management of roads. Enacted in 1894-95. Comp. by Roy Stone ...... 1895; Supplement, 1895.—no. 19. Progress of road construction in the United States ...... 1895. 1897.—no. 20. Traction tests. By S. T. Neely. 1896.—no. 21. Proceedings of the International good roads congress ...... 1901. 1901.—no. 22. Proceedings of the third annual good roads convention ...... 1902.—no. 23. Road conventions in the southern states, and object-lesson roads constructed under the supervision of the Office of public road inquiries, with the cooperation of the Southern railway ...... 1902.—no. 24. Proceedings of the North Carolina good roads convention ...... 1902. 1903.—no. 25. Proceedings of the Jefferson memorial and interstate good roads convention ...... 1902.—no. 26. Proceedings of the National good roads convention ...... 1903. 1903.—no. 27. The construction of sand-clay and burnt-clay roads. By W. L. Spoon. 1906.—no. 28. The decomposition of the feldspars. By A. S. Cushman and Prévost Hubbard. 1907.—no. 29. The construction of macadam roads. By A. B. Fletcher. 1907.—no. 30. The corrosion of iron. By A. S. Cushman. 1907.—no. 31. Examination and classification of rocks for road building, including the physical properties of rocks with reference to their mineral composition and structure. By E. C. E. Lord. 1907.—no. 32. Public-road mileage, revenues, and expenditures in the United States in 1904. By M. O. Eldridge. 1907.—no. 33. Road materials of southern and eastern Maine. By Henry Leighton and E. S. Bastin. 1908.—no. 34. Dust preventives. By Prévost Hubbard. 1908.—no. 35. The preservation of iron and steel. By A. S. Cushman. 1909.—no. 36. Descriptive catalogue of the road model exhibit. Prepared by the Office of public roads. 1911.—no. 37. Examination and classification of rocks for road building, including the physical properties of rocks with reference to their mineral composition and structure. By E. C. E. Lord. 1911.—no. 38. Methods for the examination of bituminous road materials. By Prévost Hubbard ...... and C. S. Reeve. 1911.—no. 39. Highway bridges and culverts. By C. H. Hoyt and W. H. Burr. 1911.—no. 40. The road material resources of Minnesota. By G. W. Cooley. 1911.—no. 41. Mileage and cost of public roads in the United States in 1909. By J. E. Pennybacker, jr. ...... and M. O. Eldridge. 1912.—no. 42. New Hampshire highways ...... By C. H. Hoyt. 1912.—no. 43. Highway bridges and culverts. By C. H. Hoyt ...... and W. H. Burr. 1912.—no. 44. The physical testing of rock for road building including the methods used and the results obtained, by A. T. Goldbeck and F. H. bridges. By C. H. Moorefield. 1913.—no. 46. Oil-mixed Portland cement concrete. By L. W. Page. 1912.—no. 47. Descriptive catalogue of the road models of the Office of public roads ...... 1913.—no. 48. Repair and maintenance of highways. By L. I. Hewes. 1913.

U. S. Dept. of agriculture. Office of public roads. Circular no. 14-100. Wash. [1893?]-1913 **625.709. Un3c**

87 no. illus.

No more published.

Nos. 20, 28-30, 33-36 wanting.

CONTENTS: no. 14. Addresses on road improvement. [1894]—no. 15. An act to provide for the construction of roads by local assessment, county, and state aid [in New York state. 1894]—no. 16. Highway taxation: comparative results of labor and money systems. [1894]—no. 17. Origin and work of the Darlington road league. [1895]—no. 18. Report of Committee on legislation, adopted by the State good roads convention, held in Richmond, Va., October 10 and 11, 1895. [1895]—no. 19. Traffic of the country roads. [1896]—no. 20. Comment on systems of maintaining country roads. [1896]—no. 21. Methods of constructing macadamized roads. [1896]—no. 22. [appeal for the organization of state and local road improvement societies. 1896]—no. 23. Money value of good roads to farmers, [1896]—no. 24. Highway repairing. [1896] Rev. ed. [1897]—no. 25. Brick paving for country roads. [1896]—no. 26. Going in debt for good roads. <Address delivered by Judge Thayer> 1893. [1897]—no. 27. Cost of hauling farm products to market or to shipping points in European countries. [1897]—no. 28. Addresses on road improvement in Maine, New York, North Carolina, and Illinois. [By Roy Stone. 1897]—no. 29. The forces which operate to destroy

roads, with notes on road stones and problems therewith connected. By C. L. Whittle. [1897]—no. 30. Repairs on macadam roads. By E. G. Harrison. 1898.—no. 31. Must the farmer pay for good roads. By Otto Dorner. [1898]—no. 32. State aid to road building in Minnesota. By A. B. Choate. [1898]—no. 33. Road improvement in governors' messages. [Comp. by Roy Stone. 1899]—no. 34. The social, commercial, and economic phases of the road subject. [By W. H. Moore. 1900]—no. 35. [The Higbee-Armstrong road improvement act. 1900]—no. 36. List of national, state and local road associations and kindred organizations in the United States. [1902] Rev. ed. [1902]—no. 37. The railroads and the wagon roads. By A. L. Craig. [1904]—no. 38 A study of rock decomposition under the action of water. By A. S. Cushman. [1905]—no. 39-46. Public roads ...... mileage and expenditure in 1904. [Each circular relates to a special state] 1906.—no. 47. Tar and oil for road improvement: report of progress of experiments at Jackson, Tenn. [1906]—no. 48-87. Public roads ...... mileage and expenditure in 1904. [Each circular relates to a special state] 1906-07.—no. 88. Publications of the Office of public roads, [1907] Rev. ed. [1908] 2d rev. ed., 1908.—no 89. Progress reports of experiments with dust preventives. 1908.—no. 90. Progress reports of experiments in dust prevention, road preservation, and road construction. 1909.—no. 91. Sand-clay and earth roads in the middle West. By W. L. Spoon. 1910.—no. 92. Progress reports of experiments in dust prevention and road preservation. [1910]—no. 93. Bitumens and their essential constituents for road construction and maintenance. By Prévost Hubbard. 1911.—no. 94. Progress reports of experiments in dust prevention and road preservation. 1910.—no. 95. Special road problems in the southern states. By D. H. Winslow. 1911.—no. 96. Naphthalene in road tars ...... By Prévost Hubbard ...... and C. N. Draper. 1911.—no. 97. Coke-oven tars of the United States. By Prévost Hubbard. 1912.—no. 98. Progress reports of experiments in dust prevention and road preservation, 1911. 1912.—no. 99. Progress reports of experiments in dust prevention and road preservation, 1912. 1913.—no. 100. Typical specifications for the fabrication and erection of steel highway bridges ...... 1913.

Wood, Francis. Modern road construction. Lond., 1912. **625.7 W85**

Specifications 625.7 (003)

Boston. Street dept. Contract and specifications for [Boston streets], 1881-1916. **625.7 A003b**

Bound with this are contracts for streets of Fall River, Jersey City, New York City, and Marshall County, Miss.

Byrne, Austin Thomas. Treatise on highway construction ...... the location, construction, or maintenance of roads, streets and pavements. Ed. 5, rev. and enl. N. Y., 1908. **625.7 B99a**

Contains chapter on Specifications and contracts.

Colorado. State highway commission. Bulletin no. 2-4. [Denver, 1910-14.] **625.709 C71b**

no. 4. General forms, specifications, notes, plans and rules. 1914.

Massachusetts. Highway commission. Standards, approved March 8, 1913. n. p. 1913. **625.7 A003**

Blue prints of culverts, catch basins, drains, street railway sections and macadam construction.

New York (city) Dept. of public works. Specifications for a macadam pavement on the roadway of Eleventh avenue from 155th street to the intersection thereof with the Kingsbridge road. **625.7 A003nk**

New York (state) Commission of highways. Specifications for types of roads and pavements and materials of construction used therein to be used by the New York state highway department, recommended by A. H. Blanchard and P. Hubbard to New York state department of efficiency and economy, Dec. 4, 1913. Albany, 1913. **625.709 N42s**

This is also contained in the Report of the N. Y. (state) Dept. of efficiency and economy for 1915. **(625.709 N421h)**

New York (state) Dept. of efficiency and economy. Annual report concerning matters relating to the construction and maintenance of public highways, 1915. Albany, 1915. **625.709 N421h**

[Specifications for macadam roads] 625.7 A003s

Contents: Telford road between Western and Central avenues, Albany.—Gravel road from Hammonton to Absecon, N. J.—For macadam road, Birmingham, Eng.—For macadamizing Flushing and N. Hempstead turnpike.—For the construction of Green township, [Ohio] free turnpike.—For water-bound macadam, Illinois.—For bituminous macadam, Illinois.—For a stone road in ———————— county, N. J.—For grading and laying macadam, St. Louis.—For construction of parkways, Wilmington, Del.—Specifications for Telford pavement.—For roads, etc. at Fort Wayne, Mich.—For paving through the township of Summit, N. J.

U. S. Engineer dept. [Specifications for constructing various roads, pavements, etc. in the District of Columbia and in the national parks. Wash., 1887-1906]. **625.7 A003u**

West Virginia. State road bureau. Joint bulletins, no. 2-17; comp. by State road bureau, issued by Dept. of agriculture. Charleston, W. Va., 1914-15. **625.7 W52**

no. 12-15. Standard specifications, proposed contract and bond for grading and road improvements.

Laws and Legislation 625.7 (007)

Alabama. *Laws, statutes, etc.* State highway laws of ...... Alabama, 1911: no. 1 and 10, and Road laws of Alabama, 1915. Montgomery, 1911-15. (Alabama. State highway dept. Bulletin, no. 1 and 10). **625.709 AL1b**

Brindley, John Edwin. Road legislation and administration in Iowa. Ames, Iowa. [Iowa state college of agriculture and mechanic arts, 1912] **620 A072i5 no. 28**

Colorado. State highway commission. ...... Bulletin no. 2-4. [Denver, 1910-14.] **625.709 C71b**
no. 1. Out of print.
no. 2. Road laws of Colorado. 1910.
no. 3. General rules, regulations and Highway commission act. 1913.
no. 4. General forms, specifications, notes, plans, and rules, 1914.
Probably no more issued.

Franqueville, Amable Charles Franquet, *comte.* Du régime des travaux publics en Angleterre. 2. éd. Paris, 1875. **656.209 F85d2**
4 v.
CONTENTS: t. 1-2. Chemins de fer.—t. 3. Législation des chemins de fer. t. 4.—Législation de la navigation.—Législation des bills privés.
t. 2 wanting.

Geddes, George. Observations upon plank roads, together with the general plank road law of the state of New York, as amended by the laws of 1847, 1848, 1849 and 1850. Syracuse, N. Y., 1850. **625.83 G26**

Good roads year book. [1912]-16. Wash., 1912-16. **625.7 G59**
Most of the vols. contain "State road legislation".

Highways green book. (1st, 1920). Wash., 1920. **625.7 H53**
Contains highway legislation in the United States and Federal aid road act of 1916.

Holmes, Joseph Austin. Some recent road legislation in North Carolina. Raleigh, 1899. **622.3 N81 no. 2**
(North Carolina. Geological survey, 1891. Economic paper no. 2.)

Illinois. *Laws, statutes, etc.* Laws of the state of Illinois in relation to roads and bridges in counties under township organizations. In force July 1, 1911. Springfield, Ill. 1911. **625.7 A007i2**

Illinois. *Laws, statutes, etc.* Laws of the state of Illinois in relation to roads and bridges in counties not under township organizations, in force July 1, 1911. Springfield, Ill., 1911. **625.7 A007i2**

Illinois. *Laws, statutes, etc.* Roads and bridges—revision of 1913 [an act to revise the law in relation to roads and bridges. House bill no. 843, approved June 27, 1913]. Springfield, Ill., 1914. **625.7 A007i2**

Kentucky. Dept. of public roads. Bulletins, 3-8. Frankfort, Ky., 1912-13. **625.709 K41 no. 6**
no. 4-6. Compilation of road laws and opinions other than those in Carroll's statutes, 1909.

Maryland. *Laws, statutes, etc.* Laws of Maryland relating to highways. (In Maryland. Geological survey. Report. Baltimore, 1899. v. 3.) **557.52 M36r v. 3**

Maryland. *Laws, statutes, etc.* Laws governing construction, maintenance and use of state roads; acts 1906, 1908, 1910, 1912, 1914. Baltimore, 1914. **625.7 A007m2**
Compiled by the State roads commission.

Massachusetts. *Laws, statutes, etc.* Laws relating to state highways and the supervision of telephone and telegraph companies. August, 1912. Bost., 1912. **625.7 A007m3**

Michigan. *Laws, statutes, etc.* Laws relating to highways and bridges with blank forms. 1909, 1913. Lansing, 1913. **625.7 A007m4**

Montana. *Laws, statutes, etc.* Highway laws, 1917—. **625.7 A007m**
Helena, 1917—.

Nashville commercial club. Proposed Tennessee highway law; a bill prepared by the Highway reform committee of the club, and submitted to the General assembly of [Tennessee] 1891; being a revision of, and containing the essential features of the State road congress bill, of August, 1890. Nashville, 1891. **625.7 A007u**

North Carolina. Highway commission. Recent road legislation in North Carolina. Raleigh, 1901. **622.3 N81 no. 5**
(North Carolina. Geological survey, 1891—Economic papers, no. 5)

Ohio. Highway dept. Recommendations for a new highway law as directed by House bill no. 518 of the seventy-eighth General assembly of Ohio. Columbus, 1911. **625.7 A007o**

Ohio. *Laws, statutes, etc.* Road laws of Ohio, 1915. Columbus, 1915. **625.7 A007o1**

Pennsylvania. *Laws, statutes, etc.* Digest of the general and special road laws of Pennsylvania [up to and including the session of 1895]. Harrisburg, 1896. **625.7 A007p1**
(Pennsylvania. Dept. of agriculture. Bulletin no. 18).

Pennsylvania. *Laws, statutes, etc.* Pennsylvania road laws. Harrisburg, Pa. 1906. **625.7 A007p**
Compiled by Joseph W. Hunter, state highway commissioner.
"Only such acts of Assembly as are general in their application have been included ...... I have added, as an appendix, the acts of Assembly relating to .... [first class] townships."—Introductory [note].

——— ———— Supplement. 1908. **625.7 A007pa**

Pennsylvania. *Laws, statutes, etc.* Road laws and instructions, issued by the State highway dept. Harrisburg, Pa. 1915. (Pennsylvania. Highway dept. Bulletin, no. 11). **625.709 P38 no. 11**

[Road laws of various states and countries; a collection of pamphlets.] CONTENTS: Spain,— Arkansas. — California. — Connecticut. — Iowa. — Kansas. — Louisiana. —Minnenesota. — Missouri. — New Mexico. —New York. —Oregon. — Pennsylvania. — Utah.— West Virginia. 1890-1917. **625.7 A007ro**

Stone, Roy. New road laws in the United States. N. Y., 1894. **625.7 St6N**

U. S. Congress. Joint committee on federal aid in the construction of post roads. Federal aid to good roads. Report of the committee. [Nov. 25, 1914] ...... Wash., 1915. **625.709 Un3f**
(63d Cong. 3d sess. House Doc. 1510.)
Jonathan Bourne, jr., chairman.

Utica, N. Y. Chamber of commerce. Memorial relative to a proposed amendment to the constitution of the state of New York, to enable the state to maintain its commercial supremacy by the development of a limited portion of its main highways with gravel or macadam surfaces. Utica, 1904. **625.7 A007u**

Washington (*State*) *Laws, statutes, etc.* Road laws of the state of Washington. Olympia, Wash. **625.7 A007w**
Library has: 1908, 1909, 1911.

Wisconsin. Highway commission. Bulletin no. 1, 3-4. Madison, 1911-14. **625.7 W75**
no. 1. New state aid highway law, chapter 337, laws of 1911.
no. 2. Superseded by no. 4.
no. 3. State aid highway law, sections 1317m1 — 1317m15 as amended, 1913.
no. 4. Instructions to county highway commissioners and foremen for building state aid roads in 1914.

Wisconsin. Legislature. Special joint committee on highways. Report together with a bill providing for state aid in constructing and improving highways. January 14, 1910. Madison, Wis., 1910. **625.7 W75r**

Handbooks 625.7 (02)

Blanchard, Arthur Horace. *ed.* American highway engineers' handbook. N. Y., 1919. **625.7 A02b**
Bibliography at end of each section.

Harger, Wilson Gardner. Handbook for highway engineers containing information ordinarily used in the design and construction of roads warranting an expenditure of $5,000 to $30,000 per mile, by Wilson G. Harger and Edmund A. Bonney. Ed. 2. N. Y., 1916. **625.7 H224H. 2**

——— —————. Ed. 3. 1919. CONTENTS: Principles of design.—Practice of design and construction.—Specifications.—General tables.—Traffic rules and regulations. **625.7 H224H. 3**

——— —————, N. Y., 1912. CONTENTS: Part 1. Theory of design. Part 2. Practice of design and construction. **625.7 H224H**

Hubbard, Prévost. Highway inspectors' handbook. N. Y., 1919. **625.7 A02h**

Tucker, James Irwin. The American road; a non-engineering manual for practical road builders ...... treating the construction, administration and economics of improved earth roads. Norman, Okl., 1916. **625.7 A02t**

Terminology 625.7 (03)

Boulnois, Henry Percy. A glossary of road terms. Lond., 1914. **625.7 A03b**
"Published in the columns of the Surveyor."

International road congress. 3d. Lond., 1913. Terminology adopted, or to be adopted in each country relating to road construction. 1913. **625.7 A063i3 v. 3**
(Communication in v. 3 of Reports of the congress).

Periodicals—Transactions of Societies 625.7 (05)

American society of municipal improvements. Proceedings of the ... annual convention of the American society of municipal mprovements ...... (1st date) Milwaukee, 1894-date. **M 628.05 A37**
1894, 1903 and 1910 are wanting.

American road builders' association. Proceedings of the ... annual convention, 1911-13, 1917. N. Y., 1911-17. **M 625.705 A37**
Notices and proceedings of the association are included in "Good roads."

Better roads and streets. v. 4-10, 1914- Nov., 1920. Dayton, O., 1914-20. **M 625.7 B46**
Absorbed by Tractor, 1920.

California. Department of engineering. Highway commission. California highway bulletin. (1st-5th issue), 1912-1916. Sacramento, [1912]-1916. **M 625.705 C12**

Good roads. An illustrated monthly magazine devoted to the improvement of the public roads and streets. v. 1-6, v. 7. no. 1-3; Jan. 1892-Mar. 1895. N. Y., League of American wheelmen, 1892-93. Bost., League of American wheelmen, 1894-95. **M 625.705 G62**
Merged into L. A. W. bulletin (later Good roads).

Good roads; devoted to the construction and maintenance of roads and streets, 1896-date v. 23-date., 1896-date. **M 625.705 G63**
v.31-v. 41, no. 6 (new ser. v. 1-v. 12, no. 6) 1900-June, 1911.
v. 41, 1911-date (3d ser. v. 1-date) 1911-date.
Continuation of "Elliott's magazine, including L. A. W. bulletin and Good Roads."

Highway contractor and road builder; a publication for contractors, engineers and officials. [monthly] v. 1-8; 1914-1917. Albany, 1914-1917. **M 625.705 H35**
Official bulletin of New York state road builders' association.
v. 1, 5, 8; 1914, 1916, 1917 incomplete.

Highway magazine. [monthly]. v. 6-date; Feb. 1915-date. Middletown, Ohio, 1915-date. **M 625.705 H42**
v. 6-7 incomplete.

Illinois highways; official publication of the State highway department. [monthly]. v. 1-4, no. 6; 1914-17. Springfield, 1914-17. **M 625.705 I45**
Discontinued with v. 4, no. 7, July, 1917.

Municipal engineering. v. 1-date. June, 1890-date. Indianapolis, N. Y., 1890-date. **M 628.05 M92**
Title varies.

Municipal engineers journal. [monthly excepting July, Aug.] May, 1915-date v. 1-date. N. Y., 1915-date. **M 628.05 M93**
Issued by Municipal engineers of the City of New York.

Municipal engineers of the city of New York. Proceedings. 1903-15. N. Y., The Society, 1904-16. **M 628.05 M94**
——— Index, 1903-1915, pub. in Municipal engineers journal, v. 2, no. 1.

New York highway news. [Irregular] v. 1, Sept. 1913—Dec. 1914. Albany, New York State highway commission, 1913-14. **M 625.705 N42**
No more published.

Surveyor and municipal and county engineer. [weekly] 1900-date. v. 17-date. Lond., 1900-date. **M 628.05 S78**

Road Guides—Directories 625.7 (058)

Automobile club of America. Tour book. N. Y., 1911. **625.7 A058a**

Denver. Chamber of Commerce. Highways of Colorado, official guide and tour book, issued under authority of the Colorado state highway commission, C. P. Allen, chairman, text furnished by the Good roads bureau of the Denver chamber of commerce. Denver, Col., 1912. **625.7 A058c2**

Good roads year book. [1912]-16. Wash. 1912-16. **625.7 G59**
Most of the vols. contain Directories of road contractors.

The Hartford rubber works co. Automobile good roads and tours . . . Hartford, Conn., 1905. **625.7 A058h**

Congresses 625.7 (063)

American road congress. Proceedings of the [first]—fourth American road congress under auspices of American highway association, American automobile association. 1911-1914. Baltimore, 1912-15. **625.7 A063a**
1911 title reads: Papers, addresses and resolutions before the American road congress.
No more published.

Conference of the State commission. Division engineers, section superintendents, district supervisors and the county superintendents of highways of the State of New York. Proceedings. [semi-annual] 1st-3d; 1909-1910, Albany, 1909-1910. **625.7 A063co**

Congress of American road builders. *1st. Seattle, Wash.*, 1909. Modern road building, being reports of the transactions. N. Y., [1909?] **625.7 A063c**

Convention of road superintendents of the Province of British Columbia. Minutes of the proceedings, 1st-1912. Victoria, B. C., 1912. **625.7 A063cn**

Harris, George Montagu. The first International road congress. Paris, 1908. By G. Montagu Harris . . . . . . and H. T. Wakelam . . . . . . Lond., [1909?] **625.7 A063h**

International road congress. *1st. Paris*, 1908. Catalogue et notices relatives aux objets exposés. Paris, 1908. **625.7 A063ic**

International road congress. *1st. Paris*, 1908. Compte rendu des travaux du Congrès. Paris, 1909. **625.7 A063ia**

International road congress *1st. Paris*, 1908. 1er congrès international de la route. Paris, 1908. **625.7 A063i**
101 pamphlets in 3 portfolios.
Some papers in English, many French papers have summary in English.
CONTENTS: 1. section: Construction et entretien. 72 pamphlets.
no. 1-7. Rapports généraux sur les questions nos; 1 à 4 inclusivement.
no. 8-70. Rapports spéciaux sur chaque question [nos. 1 à 4 inclusivement] 1. question: La route actuelle (Assiette, choix du revêtement, procédés d'exécution, prix de revient, examen critique). 2. question: Procédes généraux d'entretien (Chaussées empierrées, chaussées pavées, chaussées diverses) 3. question: Lutte contre l'usure et la poussière (Nettoiement et arrosage, utilisation du goudron, utilisation de produits divers, résultats techniques et économiques) 4. question: La route future (tracés, profils en long et en travers, revêtements, virages, obstacles divers, pistes spéciales, etc.)
2. section: Circulation et exploitation. 29 pamphlets.
no. 71-74. Rapports généraux sur les questions no 5 à 8 inclusivement.
no. 75-98. Rapports spéciaux sur chaque question [no. 5 à 8 inclusivement] 5. question: Effets des nouveaux modes de locomotion sur les chaussées (dégradations dues à la

vitesse, dégradations dues au poids, influences des pneus, des bandages, des antidérapants, de l'échappement, de la dépression, etc.) 6. question: Effets des chaussées sur les véhicules (détériorations des organes, dérapage, etc.) 7. question: Les signaux de la route (bornage kilométrique, indications de direction, de distance, d'altitude, obstacles, points dangereux, etc) 8. question: la route et les services de transports mécaniques (transports en commun, transports industriels, voies de tramways.)

International road congress. *1st, Paris,* 1908. Communication[s] ...... Paris, 1908. 625.7 A063ib

9 nos. in 1.

CONTENTS: [1] Emploi des machines pour l'entretien des chemins vicinaux, par A. Duchesne.—[2] Construction des chaussées dans les tourbières des Pays-Bas, par Gelinck.—[3] Transport sur routes de gros chargements par G. Hevesy.—[4] Le développement des routes en Hongrie (étude historique) par C. Incze.—[5] Note sur la modification du profil transversal des routes nationales en vue de satisfaire aux besoins de la circulation automobile, par Moreau.—[6] Développement de la résistance des ponts-routes en Hongrie, par F. de Novák.—[7] Un nouveau système de pavage des routes, de André Charles.—[8] Le procédé d'amenagement des routes, par Maurice de Redon de Colombier.—[9] Un revêtement nouveau pour la route future, de Valentin Conti.—Note sur la cuirasse Decauville en briques de ciment pour la protection des talus des routes, par Paul Decauville.

With these are bound the following: The future road, the wearing surface, by P. W. Henry.—Application du procédé transformation des bois "Managnan" au pavage des chaussées par managnan & Tolmer.—Rapport sur un chemin de fer unirail dit "Isopédin", par R. Snyders.

International road congress. *2d, Brussels,* 1910. Highway engineering, by Arthur H. Blanchard and Henry B. Drowne, N. Y., 1911. 625.7In8

International road congress. *2d, Brussels,* 1910. Reports and Communications. Paris, 1910. 625.7 A063i2

v. 1. General reports.
v. 2. Questions.
1. Section: Construction and maintenance.
Division A: Construction and maintenance outside of large towns.
no. 1. Metalled and paved roads.
2. Foundations and drainage of roads, methods of carrying out of work.
3. Laying light railways and tramways on roads.
Division B: Construction and maintenance in the large towns.
no. 4. Cleansing and watering.
no. 5. Choice of the surfacing materials.
6. Methods of carrying out road work in connection with lighting and water supply.
2. Section: Use and Traffic.
7. Influence of weight and speed of vehicles on special structures.
8. Road vehicles.
9. Conditions for the use of public service conveyance other than tramways.
v. 3. Communications:
1. Section: Construction and maintenance. Report on road administration, by J. E. Pennypacker.
no. 1. Use of mechanically driven petrol motor rollers.
2. Road making tools and implements other than mechanically driven rollers. Scarifiers, etc.
3. Various materials in use for the purposes of construction and maintenance.
4. Construction of footways in towns.
5. Removal of snow and ice.
2. Section: Use and traffic.
6. Road signs.
7. Various kinds of soft tyres.
8. Census of traffic and tonnage.

International road congress. *2d, Brussels,* 1910. Report on the proceedings of the congress. Paris, 1911. 625.7 A063i2a

International road congress. 3d, Lond., 1913. 625.7 A063i3a
Report of the proceedings of the congress. Rennes, 1913.

International road congress. 3d, Lond., 1913. 625.7 A063i3
Reports ...... Communications. Paris, 1913.
1st. Sec. v. 1. Construction and maintenance.
(1) Planning of new streets and roads.
(2) Types of surfacing to be adopted on bridges, viaducts, etc.
(3) Construction of macadamized roads bound with tarry, bituminous, or asphaltic materials.
v. 2. (4) Wood paving.
(5) Methods of lighting public highways and vehicles.
(6) Observations noted since 1908 as to various causes of wear and deterioration of roadways.
(7) Regulations for fast and slow traffic on roads.
(8) Authorities in charge of the construction and maintenance of roads.—Functions of central authorities and local authorities.
(9) Finance of the construction and upkeep of roads.—Provision of revenues.
v. 3. Communications.—Machinery used in the construction of macadamized roads.—Test of materials used in macadamized roads.—Construction of waterbound macadamized roads.—Technical and economic study of the comparative advantages of different types of roads.—Various types of stone paving in use.—Direction and distance of sign posts.—Development since the 2d congress of self-propelled public service vehicles.—Qualifications of engineers and surveyors in charge of roads.—Statistics of cost of construction and maintenance.—Terminology adopted, or to be adopted in each country relating to road construction.

International road congress. 3d, Lond., 1913. **625.7 A063i3b**
Resolutions expressing the conclusions of the Third international road congress as to to the nine (9) questions which were presented for discussion. n. p., 1913.

Irish roads congress, *2d, Dublin,* 1911. Record of proceedings. Dublin, 1911. **625.7 A063ir**

New York (city) Board of estimate and apportionment. Report of the chief engineer on the First International road congress, Oct. 11-18, 1908. N. Y., 1908. **625.7 A063id**

New York (city) Board of estimate and apportionment. Report of the chief engineer on the Third International road congress, held in Lond., June 23-28, 1913. N. Y., 1913. **625.7 A063I3c**

Pan-American road congress, *Oakland, Cal.,* 1915. Proceedings of the congress, held under the joint auspices of the American road builders' association and the American highway association with the coöperation of the Pacific highway association and the Tri-state good roads association. N. Y., [1915?] **625.7 A063pr**

Permanent international association of road congresses. Bulletin. [quarterly], no. 1-13. Paris, 1911-19. **625.7 A063pb**

Permanent international association of road congresses. [Publications; a collection of pamphlets.] Paris, 1910-14. **625.7 A063p**
CONTENTS: Listes des membres, 1912-13.—Reports of the Executive committee on the general state of association. 1909-14.—Minutes of proceedings, Permanent international commission, 1910-11.—Experiments in dust prevention, road preservation and road construction.—Bituminous materials in road construction.—Competition for encouraging improvement in the methods of road maintenance.

History 625.7 (09)

Aitken, Thomas. Road making and maintenance: practical treatise for engineers, surveyors, and others; with an historical sketch of ancient and modern practice. Lond., 1900. **625.7 Ai9**

Gt. Brit. Road board. Annual report. Library has 1910-11, 1911-12. **625.7 A009g**

Special Places

England

Ryves, Reginald Arthur. The king's highway. The nature, purpose, and development of roads and road systems. Lond., 1908. **625.7 R98**

Webb, Beatrice. English local government; the story of the king's highway, by Beatrice and Sidney Webb. N. Y., 1913. **625.7 A09w**
Notes and references at end of each chapter. Covers England and Wales.

France

Rockwell, Alfred Perkins. Roads and pavements in France. N. Y., 1896 [1895]. **625.7 R59**

France. Departement de la Seine. Devis de fournitures de pavés neufs à faire due ler octobre, 1876, au 31 décembre, 1880, pour les voies publiques de Paris. Paris, 1876. **625.709 F84**

France. Departemente de la Seine. Devis et cahier des charges de l'entreprise des travaux d'entretien et de construction des trottoirs et dallages en granit, lave et pavés, et des urinoirs appliques dépendant du Service municipal des travaux publics de Paris, du Ier janvier, 1878, au 31 décembre, 1882. Paris, 1877. **625.709 F84**

France. Departement de la Seine. Municipal service of works in Paris; detailed price list and prescribed charges for the construction and maintenance of footpaths and pavements in bitumen and of the areas and roads in compressed asphalt belonging to the municipal service from the 1st January, 1872 to the 31st December, 1877. Paris, 1872. **625.709 F84**

France. Departement de la Seine. Service municipal des travaux de Paris; devis et cahier des charges de l'entreprise des travaux d'entretion et de construction des trottoirs et dallages en bitume, et des aires et chaussées en asphalte comprimé, dépendant du Service municipal, du Ier janvier, 1878, au 31 décembre, 1882. Paris, 1877. **625.709 F84**

Italy

Italy. Direzione generale di ponti e strade. Relazione sulla viabilità ordinaria al 30 giugno, 1904. Roma, 1905. **q625.7 It1**

Italy. Ministero dei lavori publici. Cenni monografici dei singoli servizi. Roma, 1878. **620.09 It12**
4 v. Tables, maps, diagrs.
Compilati in occasione della Esposizione universali di Parigi dell' anno 1878.
CONTENTS:
v. 1. pt. 1. Relazione generale.
pt. 2. Strade ordinarie.
pt. 3. Strade ordinarie (provinciali e comunali).
v. 2. pt. 4-5 sui consorzi idraulici di scolo e dizesa in Italia.

pt. 6. Navigazione interna.
v. 3. pt. 7 Consorzi idraulici di terza categoria.
pt. 8. Bonificazioni.
v. 4. 9 pt. Porti italiani.
pt. 10. Edilita.
pt. 11. Poste italiane.
pt. 12. Telegrafi.

Italy. Ministero dei lavori pubblici. Relazione sulle costruzioni di strade nazionali e provinciali eseguite dallo stato o col concorso di esso nel periodo dal 1° gennaio 1884 al 30 giugno 1885. Roma, 1886. 625.709 It6c

Italy. Ministero dei lavori pubblici. Relazione sulle strade comunali obbligatorie per l'anno, 1875-82, 84-89. 625.709 It6
Roma, 1876-1890.

Switzerland

Bern (Switzerland). Direction der offentlichen bauten. Statistik eines theiles der kantonalen bauverwaltung, 1875. Bern, 1875. 625.7 A009be

Siam—Cape of Good Hope

Siam. Dept. of ways. Annual report. 2d.—1920-1921. Bangkok. 625.7 A009si

Cape of Good Hope. Dept. of public works. Reports upon proposals for road administration in the Transkeian Territories. Cape Town, 1907. 625.709 C17

Canada

Highways green book. (1st, 1920). Wash., 1920. 625.7 H53
Contains bibliographies.

Ontorio. Dept. of public works. Annual report on highway improvement. 625.7 A009or
Library has 1904-12.

Ontario. Department of public highways. Report on street improvement, 1917. Toronto, 1917. 625.709 On8

Ontario. Public roads and highways commission. Report, 1914. Toronto, 1914. 625.7 A009on

Nova Scotia. Highways board. Report. 1st-2d; 1918-19. 625.7 A009no2
Halifax, N. S., 1919-20.

Nova Scotia. Road commissioner and provincial engineer. Annual report of the highways division of the Dept. of public works and mines and of the larger bridges and subsidized railways, 1914-17. Halifax, N. S., 1915-18. 625.7 A009no
For later reports see Nova Scotia. Highways board.

Nova Scotia. Road commissioner and provincial engineer. Bulletin. no. 1-3. Halifax. N. S., 1915-17. 625.7 A009no 1914 and 1916.
(In Nova Scotia. Road commissioner and provincial engineer. Annual report, 1914 and 1916).
no. 1. Earth roads.—no. 2. Road construction.—no. 3. Road grader, its uses and abuses, by W. L. Bishop.

Mexico—Cuba

Mexico. Direccion general de obras publicas del Distrito federal. Los pavimentos de la ciudad de Mexico. Reseña documentada. México, 1907. 625.7 M57

Morales y Pedroso, Luis. El sistema de alcantarillado y pavimentacion de la ciudad de la Habana. (Conferencias leídas en la Sociedad cubana de ingenieros) 1916. Habana, [1916] 628.209 M79

United States

Kingsford, William. History, structure and statistics of plank roads, in the United States and Canada; with remarks on roads in general by F. G. Skinner; and a letter on plank roads by Charles E. Clarke. Phil., 1851. 625.83 K61

Lincoln highway association, pub. Signs of the times on the Lincoln way. Detroit, 1913. 625.709 L63
With this is bound: The Lincoln highway, its ideals, plans and purposes.

[Roads; a collection of pamphlets made up of various municipal and state reports.] 1865-1916. 625.7 O009ro
CONTENTS: Norwich, Conn.—Brookline, Mass.—Nashville, Tenn.—Oakland, Cal.—Colorado Springs, Colo.—Boston.—Maryland state roads commission.—Cambridge, Mass.—Virginia state highway commission.—Baltimore.—Wilmington, Del.—Medford, Mass.—Rhode Island state board of public roads.—St. Louis.—Burlington, Vt.—Lafayette, Ind.

Shaler, Nathaniel Southgate. Preliminary report on the geology of the common roads of the United States. Wash., 1895. 557.3 Un3r v. 15
Extract from the 15th annual report of the U. S. Geological survey, 1893-94.

Stone, Roy. New roads and road laws in the United States. N. Y., 1894. 625.7 St6N

U. S. Congress. Joint committee on federal aid in the construction of post roads. Federal aid to good roads. Report of the committee [Nov. 25, 1914] ...... Washington, (63d Cong., 3d sess. House. Doc. 1510). **625.709 Un3f**
Jonathan Bourne, jr., chairman.

U. S. Congress. Senate. Reports and draughts of surveys for the improvement of harbors and rivers and the construction of roads and canals, with messages and other documents relating to the same; to which are added brief extracts from the Journals of the Senate and House of representatives. Wash., 1839. **627.09 A007u**
2 v.
v. 1. 1789-1823.
v. 2. 1823-1827.

U. S. Congress. Senate. Committee on post offices and post roads: Interstate highway system. Hearings before the committee on S. 1355. Wash., 1921. **625.709 Un33**

U. S. Engineer dept. National road from the Aqueduct bridge to Mount Vernon, Va. Letter from the secretary of war, transmitting, with a letter from the chief of engineers, a report of a survey for a national road from the Aqueduct bridge to Mount Vernon, Va. Wash., 1890. (51st Cong., 1st sess. House. Ex. doc. 106). **625.709 Un3**
Report of Lieut. Col. Peter C. Hains, with appended report of B. F. Mackall.
"Charter of the Mount Vernon avenue association": p. 17-19.

Maine—New Hampshire—Vermont

Maine. State highway commission. Annual report. **625.7 A009m**
Library has 1905-16.

New Hampshire. Dept. of highways. Biennial report of the Governor and council and of the State dept. of highways relative to highway improvement. **625.7 A009n3**
Library has 1905/06, 1908/09-1912/13, 1917/18-1919/20.

Vermont. Highway commission. Report [biennial]. **625.7 A009v**
Library has 1901/02, 1905/06-1915/16.

Massachusetts

Massachusetts. Highway commission. Annual report for the fiscal year ending Nov. 30. **625.7 A009m3**
Library has 1892-date.
1897 and 1899 are wanting.

Somerville, Mass. Street commissioner. Annual report. **625.7 A009so**
Library has 1900-03, 1916, 1919-20.

Springfield, Mass. Superintendent of streets and sewers. Annual report. **625.7 A009s**
Library has 1884, 1889, 1892-1910.

Boston. Street dept. Contract and specifications for [Boston streets]. 1881-1916. **625.7 A003b**
Bound with this are contracts for streets of Fall River, Jersey City, New York City and Marshall County, Miss.

Boston. Street dept. [Contract and specifications for pavements. 1891-1893.] **625.8 A003b**
CONTENTS: Furnishing paving bricks.—Large paving-blocks.—North-river flagging.—Furnishing stone to the city crushers.—Teaming crushed stone.—Repairing asphalt pavements for the city of Boston.—Surfacing drives and walks on the parkway between Tremont and Perkins streets.—Laying a brick wall at Charlesbank.
The last two were issued by the Dept. of parks.

New Bedford, Mass. Superintendent of streets. Annual report. **625.7 A009ne2**
Library has 1902-11.

Rhode Island—Connecticut

Rhode Island. Board of public roads. Annual report. **625.7 A009r**
Library has 1903-15.

Providence. Surveyor of highways. Quarterly report. May 31, 1870-Feb. 28, 1871. **625.7 A009pr**
Providence, 1870-71.
Title of report for Nov. 30th, 1870 reads: Annual report.

Connecticut. Highway commissioner. Report. [annual]. **625.7 A009c3**
Library has 1901-1908, 1913-date.

New York State

Geddes, George. Observations upon plank roads, together with the general plank road law of the state of New York, as amended by the laws of 1847, 1848, 1849 and 1850. Syracuse, N. Y., 1850. **625.83 G26**

Merrill, Frederick James Hamilton. Road materials and road building in New York. Albany, 1897. **507.4 N42b no. 17**

New York (state) Commission of highways. Bulletin containing practical suggestions and directions to highway officers relating to the construction, improvement and maintenance

of town highways and bridges, the Highway law of 1908, as amended, and the Motor vehicle law, by F. D. Lyon. (Bulletin no. 1.) N. Y., 1910. **625.709 N42b**
Binder's title reads: Road red book.
The Road red book for 1906 was issued as Bulletin no. 12, by the State engineer and surveyor. (625.709 N42 no. 12).

New York (state) Commission of highways. Instructions to employees, prepared in accordance with the Highway law. Albany ,1914. **625.709 N42i**
v. 1. General instructions, construction work, maintenance and repair, expense accounts.
v. 2. Surveys, office work.

New York (state) Commission of highways. Report of the Board of consulting engineers, 1913; final report. Albany, 1913. **625.709 N42r**
On the history and proper organization of the Dept. of highways.

New York (state) Commission of highways. Report of the State commissioner of highways. [annual]. **625.7 A009n6**
Library has 1909-18.

New York (state) Commission of highways. Specifications for types of roads and pavements and materials of construction used therein to be used by the New York state highway department, recommended by A. H. Blanchard and P. Hubbard to New York state department of efficiency and economy, Dec. 4, 1913. Albany, 1913. **625.709 N42s**
This is also contained in the Report of the N. Y. (state) Dept. of efficiency and economy for 1915. (625.709 N421h.)

New York (state) Commission of highways. Tables giving detailed information and present status of all state and county highways, plans for which have been approved by the Highway commission and Boards of supervisors of the respective counties in which they are located. 1915, 1917. Albany, 1916-18. **625.709 N42t**
Issued as the Official bulletin for 1915 and 1917.

New York (state) County supt. of highways. Good roads of Monroe county, N. Y. Rochester, 1915. **625.709 N42g**

New York (state) Dept. of efficiency and economy. Annual report concerning matters relating to the construction and maintenance of public highways, 1915. Albany, 1915. **625.709 N421h**
Apx. 5-8 contain Specifications recommended to the Highway dept., Dec. 4, 1913.—Highway commission specification for bituminous material A, discussed at conference on Jan. 6, 1914.—Specifications adopted Jan. 15, 1914 for top course bituminous macadam.—New specifications recommended by Advisory board.

New York (state) State engineer and surveyor. Improvement, repair and maintenance of public highways; bulletins, no. 1-12. 1899-1906. Albany, The State, 1899-1906. **625.709 N42**
Bulletin no. 12 has binder's title: Road red book.
Bulletins 4-6 and 9 contain Proceedings of the Good roads convention of the Boards of supervisors of the state of New York for 1902-05.

New York highway news. [Irregular.] v. 1, Sept. 1913-Dec. 1914. **M625.705 N42**
Albany, New York State highway commission, 1913-14.
No more published.

[Roads and pavements of New York; a collection of pamphlets.] 1876-1911. **625.709 R531**
CONTENTS: State highways, by Good roads committee of the Board of supervisors of Monroe county.—Pavement question, by City engineer of Syracuse.—Report on pavements, by the City engineer of Canadaigua.—Report of investigation of proposed pavements for East avenue by City engineer of Rochester.—Pavements in the city of Binghamton, by the Binghamton chamber of commerce.—Construction and repair of sidewalks, curbs and gutters, by Poughkeepsie Board of public works.—Maintenance of pavements and administration of streets in the city of New York, by the Merchants' association of New York.—Table showing length of streets regulated and graded (in New York city) from 1871 to 1898.—Report on the twenty-third and twenty-fourth wards, by the New York city Dept. of public works.—Improvement of the street pavements in the business part of the city, by the New York Chamber of commerce.—Street pavements, by the Grahamite and Trinidad asphalt pavement company.

New York (city) Dept. of public works. Article on street pavements. N. Y., The city, 1891. **625.8 N42**
Thomas F. Gilroy, Commissioner of public works.
Most of this material appeared in the Report of the Dept. for the quarter ending Dec. 31, 1890.

New York City

Brooklyn. Dept. of city works. Annual reports, Brooklyn. Includes reports of Engineer of street construction and maintenance and Superintendent of streets superintendent of supplies for 1873-74, 1875-77, 1879-82, 1887-92, 1894-96. **628.109 N428r6**

Grant, William Harrison. Roads and walks of Central park in the city of Now York; being a description of their mode of construction, etc., adapted to general application in making public and private roads and walks. 1865. **625.8 G76**

Memorandum of asphalt pavements laid in New York up to January 1, 1898. n. p., 1898. **625.8 G76**

New York (city) Bronx borough. Public works commissioner. Report on White Plains road experimental pavements, by W. H. Connell. N. Y., 1911. **625.7 N42**
v. 2 consists of Photographs of cross sections of the White Plains road experimental pavements.

New York (city) Commissioner of accounts. Asphalt paving. N. Y., 1904. 625.809 N42
Signed: John C. Hertle, William Harman Black, commissioners of accounts.
"Reproduction of the Report of an investigation of asphalt paving, dated May 9, 1899": p. [165]-224.

New York (city) Commissioner of accounts. Report on concrete foundations for pavements with special reference to work of that nature in the Borough of Brooklyn, during the year 1902. N. Y., 1903. 625.7 A009ne8

New York (city) Dept. of highways. Annual report. 625.7 A009ne9
Library has 1898-1901.

New York (city) Dept. of public works. Proposals for estimates for regulating and grading 109th street from 8th to Manhattan avenues, and setting curb stones and flagging sidewalks therein. N. Y., 1888. 625.709 N423

New York (city) Dept. of public works. Proposals for regulating and paving with asphalt pavement on concrete foundation. N. Y., 189 . 625.8 A003np
Also Proposals for regulating and paving with asphalt on the present (189 ') pavement.

New York (city) Dept. of parks. Report upon concrete pavements, principally with regard to compositions in which bituminous material is used. n. p., 1872. (Document no. 37). 625.8 G76
Report of a Board of engineers representing the Park Boards of New York, Brooklyn, Philadelphia, Buffalo and Washington.

New York (city) Dept. of public works. A repair plant for asphalt pavements for the borough of Manhattan; recommended by George Livingston, commissioner of public works, with an appendix embodying the result of an expert investigation by J. C. Bayles. N. Y., 1903. 625.761 N43

New York (city) Dept. of public works. Report on street pavements with special reference to asphalt pavements, 1892. N. Y., 1892. 625.85 N43
An extract from the Report of the dept. for 1891.

New York (city) Dept. of public works. Specifications and proposals [for paving N. Y. streets with granite, or trap-block pavement. [1875-88] 625.82 N42
A collection of specifications bound in one volume.

New York (city) Dept. of public works. Specifications for a macadam pavement on the roadway of Eleventh avenue from 155th street to the intersection thereof with the Kingsbridge road. 625.7 A003nk
Manuscript.

New York (city) Queens borough, Bureau of highways. Contract, including notice to contractors, bid or proposal, contract, bonds, certificates, and specifications, for regulating, grading, curbing, and paving with asphalt blocks on a concrete foundation, together with all work incidental thereto. N. Y., 1908. 625.8 A003nb

Stokes, William E. Dodge. Final argument before the Board of estimate and apportionment of the city of New York, in favor of finishing the pavement of the Grand boulevard from 59th to 110th sts., with asphalt, out of the appropriation for 1889. n. p., 1889. 625.8 G76

Pennsylvania—New Jersey—Delaware

Pennsylvania. Highway dept. Bulletin no. 1-11, 1910-15. [Harrisburg?], 1910-15. 625.709 P38

Pennsylvania. Highway dept. Report [annual]. 625.7 A009p
Library has 1904-17.

Pennsylvania. Highway dept. Report of the State highway commissioner to the House of representatives of Pennsylvania, Feb. 5th, 1913, required by the resolution adopted by the House of representatives, Jan. 22, 1913. Harrisburg, 1913. 625.7 A009p2

Pennsylvania. *Laws, statutes, etc.* Pennsylvania road laws. Harrisburg, Pa., 1906. 625.7 A007p
Compiled by Joseph W. Hunter, state highway commissioner.
"Only such acts of Assembly as are general in their application have been included. I have added, as an appendix, the acts of Assembly relating to [first class] townships." —Introductory [note].
——— ——————— Supplement. 1908. 625.7 A007pa

Philadelphia. Bureau of highways and street cleaning. Highways; a problem in municipal housekeeping. Report for 1914. n. p., 1915. 625.7 A009ph

Philadelphia. Bureau of highways and street cleaning. Highways; paving, cleaning and upkeep. Summary of operations for year 1916. n. p., 1917. 625.7 A009pb

New Jersey. Commissioner of public roads. Annual report. 1st-24th; 1894-1817. Trenton, 1894-1917. 625.7 A009n4
In 1917 name was changed to State highway dept.

Jersey City. Dept. of streets and public improvements. Annual report. 625.7 A009j
Library has 1895-1911, 1913-14, 1916-17.

Newark, N. J. Dept. of streets and public improvements. Annual report, 1891-1918. 625.7 A009n
1900-02 are wanting.
Name varies: 1891-1893 Committee on the dept. of water of the Board of street and water commissioners; 1894-1916 Board of street and water commissioners.

Delaware. State highway dept. Delaware state highways; the story of roads in Delaware from the days of the "beasts of burthen" to "The road of to-morrow". Delaware state program, 1919. 625.709 D37

Southern States

Baltimore and Fredericktown turnpike road company. Laws, documents and judicial decisions relating to the Baltimore and Fredericktown, York and Reisterstown, Cumberland and Boonsborough turnpike road companies. Baltimore, 1841. **625.709 B21**

Maryland. Geological survey, 1896. Report on the highways of Maryland. Baltimore, 1899. **625.709 M36**

Same material as that in Maryland Geological survey [Report] v. 3, except that the latter contains an appendix of 80 p. on the "Laws of Maryland relating to highways." CONTENTS: pt. I. Introduction, including an account of the organization of highway investigations by the Maryland Geological survey, by W. B. Clark.—pt II. The relations of Maryland topography, climate and geology to highway construction, by W. B. Clark.—pt. III. Highway legislation in Maryland, and its influence on the economic development of the state, by St. G. L. Sioussat.—pt. IV. The present condition of Maryland highways, by A. N. Johnson.—pt. V. Construction and repair of roads, by A. N. Johnson.—pt. VI. Qualities of good road-metals, and the methods of testing them, by H. F. Reid.—pt. VII. The administration of roads, including the method and expense of road improvements, by H. F. Reid.—pt. VIII. The advantages of good roads, by H. F. Reid.

Maryland. *Laws, statutes, etc.* Laws governing construction, maintenance and use of state roads; acts 1906, 1908, 1910, 1912, 1914. Baltimore, 1914. **625.7 A007m2**

Compiled by the State roads commission.

Maryland. State roads commission. Annual report, 1st-8th; 1908-15. Baltimore, 1912-16. **625.7 A009m2a**

Baltimore county, Md. Roads engineer. Annual report, 1904-date. **625.7 A009b**

West Virginia. Dept. of public roads. First biennial report of the commissioner of public roads to the governor of West Virginia, for the period ending September 30, 1910. Charleston, 1911. **625.7 A009w4b**

Charles P. Light, commissioner.
Office abandoned in 1911.

West Virginia. State roads bureau. Annual reports, 1st- . 1913/14.—[Charleston, 1914?] **625.7 A009w4**

Report year ends June 30.
No more published (?).

West Virginia. State road bureau. Joint bulletins, no. 2-17; comp. by State road bureau, issued by Dept. of agriculture. Charleston, W. Va., 1914-15. **625.7 W52**

no. 6, 11, 16 wanting.
With these is included: The Road school, Feb. 10 to 20, 1914, West Virginia university Bulletin, series 14, no. 9.
no. 2. List of road officials.
no. 3. Road drag.
no. 4. Prison labor.
no. 5. Earth and sand clay roads.
no. 7. Study of West Virginia sands.
no. 8. Standard specifications for superstructures of steel highway bridges.
no. 9. Standard specifications, proposal contract and bond for superstructure of concrete highway bridges.
no. 10. Standard specifications, proposal, contract and bond for substructures of highway bridges.
no. 12. Information for bidders, specifications, proposal contract and bond for grading and road improvement.
no. 13. Same for macadam road improvements.
no. 14. Same for concrete road improvements.
no. 15. Information for bidders specifications, proposal, contract and bond for brick road improvement.
no. 17. Rules for prison camps, surveys and records, and a list of standard forms.

Virginia. Highway commission. Annual report of the State highway commissioner, 1905-15. **625.7 A009v2**

Good roads institute, Chapel Hill, N. C. Proceedings of the Good roads institute, held at the University of North Carolina. 1st-2d; 1914-15. Raleigh, 1914-16. (North Carolina. Geological and economic survey. Economic paper no. 39, 43.) **622.3 N81**

Holmes, Joseph Austin. Some recent road legislation in North Carolina. Raleigh. 1899. (North Carolina. Geological survey, 1891—Economic paper no. 2). **622.3 N81 no. 2**

North Carolina. Geological survey. Biennial report of the state geologist, 1891-1920. Raleigh, 1893-1920. **557.56 A009n7**

These reports include road work.

North Carolina. Geological survey. 1891. Highway work in North Carolina during the calendar year ending Dec. 31, 1914. Raleigh, 1917. (Economic paper no. 44.) **622.3 N81 no. 44**

North Carolina. Highway commission. Recent road legislation in North Carolina. Raleigh, 1901. (North Carolina. Geological survey, 1891—Economic papers, no. 5.) **622.3 N81 no. 5**

Bulletin no. 1 of the Highway commission.

North Carolina good roads convention, Charlotte, N. C., 1912. Proceedings of the annual convention, held in cooperation with the North Carolina geological and economic survey. Raleigh, 1912. (North Carolina. Geological and economic survey. Economic paper no. 30). **622.3 N81 no. 30**

North Carolina good roads convention, Morehead City, N. C., 1913. Proceedings of the annual convention, held in cooperation with the North Carolina geological and economic survey; statistical report of highway work in North Carolina during 1912. Raleigh, 1914. (North Carolina. Geological and economic survey. Economic paper no. 36.) **622.3 N81 no. 36**

Pratt, Joseph Hyde. Good roads days, November 5 and 6, 1913. Raleigh, 1914. (North Carolina. Geological and economic survey. Economic paper no. 35.) **622.3 N81 no. 35**

Pratt, Joseph Hyde. Highway work in North Carolina, containing a statistical report of road work during 1911. Raleigh, 1912. (North Carolina. Geological and economic survey. Economic paper no. 27). **622.3 N81 no. 27**

Pratt, Joseph Hyde. Public roads are public necessities. Raleigh, 1913. (North Carolina. Geological and economic survey. Economic paper no. 32.) **622.3 N81 no. 32**

South Carolina. University. Good roads. Columbia, S. C., 1910. (Bulletin, no. 20.) 625.7 So8

CONTENTS: Plea for good roads, by M. G. Homes.—Economic value of good roads, by E. J. Watson.—Relation of good roads to schools, by W. H. Hand.—Statistics of roads in South Carolina, by F. H. Hyatt.—Bonds for public highways, by D. A. Tompkins.—Road building materials, by M. W. Twitchell.—Reasons for establishing a state highway commission by F. H. Colcock.—Economic view of the good roads movement, by C. C. Wilson.

McCallie, Samuel Washington, 1856. A third report on the public roads of Georgia, Atlanta, Ga., 1912. (Georgia. Geological survey, 1890—Bulletin no. 28) **557.58 G29b no. 28**

Sellards, Elias Howard. Roads and road materials of Florida, by E. H. Sellards, H. Gunther, and N. H. Cox. Saint Augustine, 1911. (Florida. Geological survey. Bulletin no. 2.) **557.59 F66b no. 2**

Alabama. State highway dept. Bulletin. no. 1-15; 1911-18. Montgomery, Ala., 1911-18. **625.709 AL1b**

no. 13 wanting.

Bulletin no. 2 pub. also as Bulletin no. 11 of the Geological survey of Alabama.

Includes Annual reports of the State highway commission, 1st-7th; Apr. 1911-18.

Prouty, William Frederick. Roads and road materials of Alabama. Montgomery, Ala., 1911. (Alabama. Geological survey, 1873—Bulletin no. 11.) **557.61 AL1b no. 11**

Bibliography: p. 126-127.

Lowe, Ephraim Noble. Road-making materials of Mississippi, [Jackson], 1920. (Mississippi. State geoligical survey. Bulletin no. 16.) **557.62 M69b no. 16**

New Orleans. City engineer. Annual report of operations of the Municipal repair plant, New Orleans, La. 1st-3d; 1906/07-1908/09. New Orleans, 1907-09. **625.761 N42**

Christner, Drue De Garmo. The geology of Terrell County, by D. D. Christner and O. C. Wheeler; Roads of Terrell County, by O. C. Wheeler. Austin, Tex., [1918]. **622.3 T31 [no. 21]**

(Texas. University, Bureau of economic geology and technology. [Publ. no. 21].)

Paxton, Edward Thurber, ed. Street paving in Texas, [Austin, 1915]. (Bulletin of the University of Texas. **625.709 P28**

"Street paving in Texas [by L. W. Kemp]": p. [10]-17.

Potts, Robert Joseph. Benefits of good roads. Austin, Texas, 1914. (Texas agricultural and mechanical college. Bulletin. n. s. v. 2, no. 1) **625.7 P85**

Texas. Agricultural and mechanical college. Engineering experiment station bulletin. College Station, 1915-20. **620 T31**

no. 2, 4-9, 11, 20 wanting.
no. 1. Earth roads.
no. 3. Highway bridges and culverts.
no. 10. Sewage disposal for country homes.
no. 12. Demonstration roads at the Agricultural and mechanical college of Texas.
no. 13. Financial side of road improvement.
no. 14. Highway engineering at the Agricultural and mechanical college. Session 1916-17.
no. 15. Organization of a state highway dept. for the state of Texas.
no. 16. Maintenance of earth, sand-clay and gravel roads.
no. 17. Physical testing of non-bituminous road materials.
no. 18. Benefits of good roads.
no. 19. Sand-clay roads.
no. 21. Administration of highway improvements.
no. 22. Bituminous pavement investigations in certain Texas cities; pt. 1, Bithulithic.
no. 23. Principles of pavement selections with statistics of pavements in Texas, prior to Jan. 1, 1920.

Snider, Luther Crocker. Preliminary report on the road materials and road conditions of Oklahoma, Norman, 1911. (Oklahoma. Geological survey. Bulletin no. 8.) **622.3 Ok4b no. 8**

Arkansas. State highway commission. Biennial report. 1st; 1913/14. **625.7 A009a4**

Memphis, Tenn. City engineer. Statements and estimates relating to pavements, sewers, etc., showing details of cost, specifications, and other information of work done. Memphis, 1893. **625.7 A009me**

Kentucky. Dept. of public roads. Biennial report. **625.7 A009k2**

Library has 1912-13.

Kentucky. Dept. of public roads. Bulletins, no. 3-8. Frankfort, Ky., 1912-13. **625.709 K41**

no. 1. Wanting.
no. 2. Wanting.
no. 3. Information concerning the Office of Public roads.
no. 4. Compilation of road laws and opinions other than those in Carroll's statutes, 1909.
no. 5. Split-log drag.

no. 6. Compilation of road laws other than those in Carroll's statutes, 1909.
no. 7. Highway bridge lettings.
no. 8. Questions and answers.

Louisville, Ky. City engineer. Specifications for pavements, 1886-1896. 625.8 A003Lo
Specifications cover street repairs, granite streets, asphalt streets, vitrified brick or blocks.

Ohio—Indiana—Illinois—Michigan

Ohio. Highway dept. Annual report, 1st-date; 1905-date. Springfield, O., 1906-date. 625.7 A0090
Report year ends Nov. 15.
1914, wanting.

Ohio. Highway dept. Bulletin no. 1-28. Columbus, O. [etc.] 1905-15. 625.7 A0090
No. 8 to be found in the Annual report of the Ohio Highway department for 1907.

Ohio. Highway dept. General specifications for piers and abutments. Columbus, 1911. 625.709 Oh3g

Ohio. Highway dept. Recommendations for a new highway law as directed by House bill no. 518 of the seventy-eighth General assembly of Ohio. Columbus, 1911. 625.7 A0070

Ohio. *Laws, statutes, etc.* Road laws of Ohio, 1915 ...... Columbus, 1915. 625.7 A007o1

Eno, Frank Harvey. The road building materials of Coshocton County, Ohio. Columbus, O., [1912] 620 A072o no. 7
(Ohio state university College of engineering. Bulletin no. 7.)

Cincinnati, Ohio. Bureau of Municipal research. Reports. 1910-1911, Cincinnati, 1910-11. 352 A072c
CONTENTS:
no. 1 Paving report no. 1, relating to wood block paving contracts.
no. 2. Reply of Director of Public service to Paving report no. 1.
no. 3. Paving report no. 2: The Reading road contract wood block paving.
no. 6. Paving report no. 5: What is being done on Reading road.
no. 7. Reply to chief engineer.
no. 9. Street lighting report no. 1.
no. 11. The Board of health.

Blatchley, Willis Stanley. The roads and road material of Indiana. By W. S. Blatchley and assistants. (In Indiana. Department of geology and natural resources. Annual report, 1905. Indianapolis, 1906.) 557.72 In2rn v. 30

Illinois. Highway commission. Bulletin no. 1-9; 1906-12. Springfield, Ill., 1906-12. 625.709 IL6
no. 7 Wanting.
no. 1. Earth road drag, how to make it.
no. 2. Road drag law and rules for dragging.
no. 3. How to secure bridge plans.
no. 4. Crushed stone prepared by convict labor. 1909.
no. 5. General rules and regulations.
no. 6. Modern bridges for Illinois highways. 1910.
no. 8. Manual of instructions to engineers.
no. 9. Modern bridges for Illinois highways. Ed. 2, 1912.

Illinois. Highway commission. Bulletin [new series] no. 6 and 11. Springfield, 1915. 625.7 IL62
no. 6. Dust prevention.
no. 11. Surface oiling of earth roads.

Illinois. Highway commission. Illinois highways; official publication of the State highway department. [monthly] v. 1-4, no. 6; 1914-17. Springfield, 1914-17. M625.705 I45
Discontinued with v. 4, no. 7, July, 1917.

Illinois. Highway commission. Report, 1906-16. 625.7 A009i2

Illinois. *Laws, statutes, etc.* Laws of the state of Illinois in relation to roads and bridges in counties under township organization, 1911. Springfield, Ill., 1911. 625.7 A007i2

Illinois. *Laws, statutes, etc.* Laws of the state of Illinois in relation to roads and bridges in counties not under township organization, in force July 1, 1911. Springfield, Ill., 1911. 625.7 A007i2

Illinois. *Laws, statutes, etc.* Roads and bridges-revision of 1913 [an act to revise the law in relation to roads and bridges. House bill no. 843, approved June 27, 1913]. Springfield. 625.7 A007i2

Chicago. Commission on city expenditures. Preliminary report on street paving. Chic., 1910. 625.7 C43
The following are bound with this: Street pavements laid in Chicago, by the Chicago bureau of public efficiency.—Pavements recently built, by the Chicago Board of local improvements.

Michigan. Highway dept. Biennial report for 2 fiscal years ending June 30. 1st-6th; 1905-1916. Lansing, 1906-1916. 625.7 A009m4

Michigan. Highway dept. Bulletin. 1st-4th; 1910-1912. Lansing, 1910-1913. 625.709 M58
no. 1. Care of earth roads, by F. F. Rogers. 1910.
no. 2. Gravel roads, by F. F. Rogers, 1911. Ed. 2, 1913.

Michigan. Highway dept. Bulletin, cont.
no. 3. County road system, by F. G. Randall. 1911.
no. 4. Macadam roads, by F. F. Rogers. 1912.

Michigan. *Laws, statutes, etc.* Laws relating to highways and bridges with blank forms, 1909-1913. Lansing, 1913. **625.7 A007m4**

Wisconsin—Minnesota—Iowa

Buckley, Ernest Robertson. Highway construction in Wisconsin. Madison, Wis., 1903. **557.75 W75b no. 10**
(Wisconsin. Geological and natural history survey. Bulletin no. 10.)

Hotchkiss, William Otis. Rural highways of Wisconsin. Madison, Wis., 1906. **557.75 W75b no. 18**
(Wisconsin. Geological and natural history survey. Bulletin no. 18.)

Wisconsin. Geological and natural history survey. Road pamphlet ...... no. 1-5. Madison, Wis., 1907-14. **625.709 W75**
A. R. Hirst, highway engineer.

Wisconsin. Highway commission. Biennial report, 1913. **625.7 A009w2**

Wisconsin. Highway commission. Bulletin no. 1, 3-4. Madison, 1911-14. **625.7 W75**
no. 1. New state aid highway law, chapter 337, laws of 1911.
no. 2. Superseded by no. 4.
no. 3. State aid highway law, sections 1317m1—1317m15 as amended, 1913.
no. 4. Instructions to county highway commissioners and foremen for building state aid roads in 1914.

Wisconsin. Legislature. Special joint committee on highways. Report, together with a bill providing for state aid in constructing and improving highways. January 14, 1910. Madison, Wis., 1910. **625.7 W75r**

Milwaukee county, Wis. Highway dept. Annual report of the county highway commissioner. 4th-9th; 1915-1920. Milwaukee, 1916-21. **625.7 A009w25**

Minnesota. State highway commission. Bulletin; Nos. 1-2, 4-6, 8-10, 12-13. St. Paul, 1906-14. **625.709 M66b**
CONTENTS:
No. 1. Construction and maintenance of earth roads; by G. W. Cooley.
No. 2. Rules and regulations of the State Highway Commission of Minnesota.
No. 4. Better roads for Minnesota; by L. W. Page.
No. 5. Additional rules and regulations for the construction and improvement of state roads.
No. 6. Report of the State Highway Engineer on highway systems of foreign countries.
No. 8. Standard specifications for roads and culverts.
No. 9. Standard specifications for steel and concrete highway bridges.
No. 10. Additional rules and regulations for the construction and improvement of state roads.
No. 12. Road laws of Minnesota, compiled Feb., 1914.
No. 13. Rules and regulations for the maintenance of state roads, 1914.

Minnesota. State highway commission. Report. 1st-date; 1906-date. [St. Paul], 1906-date. **625.7 A009m5**

Agg, Tansy Radford. An investigation of concrete roadway, by T. R. Agg and C. B. McCullough ... Ames, Ia., 1916. **q625.84 Ag3**

Agg, Tansy Radford. Traffic Iowa highways. Ames, Ia., Iowa state college of agriculture and mechanic arts [1920]. **620 A072i5 no. 56**
(Bulletin 56, Engineering experiment station, Good roads section.)

Brindley, John Edwin. Good roads and community life in Iowa, by John E. Brindley ...... [and] John S. Dodds ...... Ames, Ia., Iowa state college of agriculture and mechanic arts [1917]. **620 A072i5 no. 39**
(Bulletin 39. Engineering experiment station. Good roads section.)

Brindley, John Edwin. Road legislation and administration in Iowa. Ames, Ia., [Iowa state college of agriculture and mechanic arts, 1912.] **620 A072i5 no. 28**
(Bulletin no. 28, Engineering experiment station.)

Iowa. Highway commission. The good roads problem in Iowa. Ames, Ia., 1905. **620 A072i5 no. 12.**
(Bulletin, Engineering experiment station of Iowa state college. vol. II, no. 6 [whole no. 12].)

Iowa. Highway commission. Report [annual] 1913-16. **625.7 A009i5**

Iowa engineering society. Brick paving in Iowa; report of the Brick paving committee [of the society]. Chic., 1902. **625.861 Io9**
Presented at the annual meeting, 1902.

Missouri—South Dakota

Buckley, Ernest Robertson. Public roads, their improvement and maintenance. Jefferson City, Mo., [1907]. **557.78 M69re v. 5**
(Missouri. Bureau of geology and mines. Reports, vol. 2d. ser.)

Harris, Elmo Golightly. Road problems in the Ozarks; with a list of publications on rural roads, comp. by Harold L. Wheeler. Ed. 2, enl. Rolla, 1919. **625.709 H24**
(Missouri. University. School of mines and metallurgy. Bulletin, v. 11, no. 3.)

Missouri. Highway dept. Road bulletins; no. 11, 13-14. Columbia, Mo., 1911-12. **625.709 M69**

Williams, Walter Scott. An investigation of the road making properties of Missouri stone and gravel, by W. S. Williams ...... and R. Warren Roberts ...... Columbia, Mo., University of Missouri, 1911. 620 A072m7 v. 2, no. 3
(Missouri. University Engineering experiment station. Bulletin, v. 2, no. 3).

South Dakota. Highway commission. Annual report. Pierre, S. Dak., 1913-14. 625.7 A009s2

Montana—Colorado—New Mexico—Arizona

Montana. Highway commission. Road pamphlet, no. 1-3. Helena, 1914. 625.7 M76

Montana. Highway commission. Report [biennial], 1917. 625.7 A009m8
Library has 1913.

Montana. *Laws, statutes, etc.* Highway laws, 1917. Helena, 1917. 625.7 A007m

Colorado. State highway commission. Biennial report. 625.7 A009c2
Library has 1909-10, 1911-12, 1913-14, 1915-16.

Colorado. State highway commission. Bulletin no. 2-4. [Denver, 1910-14.] 625.709 C71b
no. 1. Out of print.
no. 2. Road laws of Colorado, 1910.
no. 3. General rules, regulations and highway commission act, 1913.
no. 4. General forms, specifications, notes, plans and rules, 1914.
Probably no more issued.

New Mexico. Engineer dept. Report of state highway engineer and state engineer [biennial]. 1st-4th; July, 1912-Nov., 1920. [Santa Fé], 1914-20. 625.7 A009n5

Arizona. State engineer. Report. 1st-4th; July, 1909-1920. [Phoenix, 1914-21]. 625.7 A009a3
3d, 1916-18 wanting.

California—Washington—Alaska

Automobile club of southern California. The state highways of California; an engineering study conducted jointly by the Automobile club of southern California and the California state automobile association, July, 1920-January, 1921. [Los Angeles, 1921]. 625.709 Au8
Issued also with different arrangement of text and with sub-title: An engineering study conducted jointly by the California state automobile association and the Automobile club of southern California.

California. Department of engineering. Highway commission. California highway bulletin. 1st-5th issue; 1912-1916. Sacramento, [1912]-1916. M625.705 C12

California. Department of highways. Biennial report; 1895-96-1905-06. Sacramento, 1869-1906. 625.7 A009c
In 1907 the work of the Department of highways was transferred to the Dept. of engineering. For later reports see
California. Engineering dept. Report.

California. Department of highways. Oiled roads of California. (Bulletin no. 2 (2d series), Oct., 1904). 625.709 C12

U. S. Bureau of public roads. Report of a study of the California highway system to the California highway commission and highway engineer. [Baltimore], 1920. 625.709 Un37

Washington (State) Highway dept. Biennial report of the state highway commissioner. 1st-8th; 1905-1920. Olympia, Wash., 1906-21. 625.7 A009w

Washington (State) *Laws, statutes, etc.* Road laws of the state of Washington; comp. by authority of State highway board. Olympia, Wash. 625.7 A007w
Library has 1908, 1909, 1911.

Washington (State) Special investigating commission on Highway department. Report of Special investigating commission on Highway department. Report of the Board of control on state rock-crushing plants; working convicts on state roads and at crushing plants. Financial statement of the state rock-crushing plants. [Olympia, 1910]. 625.7 W27

U. S. Board of road commissioners for Alaska. Annual report. 625.7 A009u
Library has 1909-15, 1917.

Other Countries

Bell, George W. Street-paving in Sydney [wood pavements]. Sydney, 1895. 625.83 B41

Caples, W. G. Report ... upon the construction of the Calamba-Batangas road, Luzon, P. I. Wash., D. C., 1903. 623 Un3o no. 5
(United States. Engineer School. Occasional paper no. 5.)

Coane, John Montgomery. Australasian roads; on the location, design, construction and maintenance of roads and pavements. By John Montgomery Coane, Henry Edward Coane, John Montgomery Coane, jun., civil engineers, Melbourne ...... Ed. 2, rev. and enl. Melbourne, 1915. 625.7 C63a

Congreso nacional de ingenieria (1st) Buenos Aires, 1916. Primer Congreso nacional de ingeneria, celebrado desde el 23 de setiembre al 8 de octubre de 1916. Buenos Aires, 1917-18. 620 A063co
T. 3. Seción Vias de comunicación: Subsección Caminos, carreteras y calzadas.

General engineering congress. Batavia, Java, May, 1920. [Papers and reports of the congress] 6 v. in 8., 1920. 620 A063ga v. 3
Sec. 3. Building and maintenance of bridges and roads.

Sydney, New South Wales. City surveyor. Test of metals [for road pavements] used in Sydney; report presented to the Works committee, Aug., 1903. Sydney, 1903. 625.861 Sy2

Victoria, Australia. Country roads board. Annual report, 1914. 625.7 A009vi

Tools and Implements

Gellerat, E. Notice sur les compresseurs à vapeur. Paris, [1872]. 625.762 G28
Manuscript.

International road congress. 2d, Brussels, 1910. Use of mechanically driven petrol motor rollers and road making tools and implements other than mechanically driven rollers, scarifiers, etc., 1910. 625.7 A063i2 v. 3
(Communication, no. 1-2 in v. 3).

International road congress. 3d, Lond., 1913. Machinery used in the construction of macadamized roads, 1913. 625.7 A063i3 v. 3
(Communications. v. 3).

Jenkins, Rhys. Power locomotion on the highway; a guide to the literature relating to traction engines and *steam road rollers* and to the propulsion of common road carriages and velocipedes by steam and other mechanical power. Lond., [1896]. 016.62114 J41

Sidewalks 625.7116

Beery, P. B., comp. Portlandt cement side-walk construction; based upon the experience of many successful contractors. ed. 2. Chic., 1904. 625.71 B45
The following are bound with this: Specifications for construction of concrete sidewalks, curbs, &c., of Clarksdale, Miss.—Cement sidewalk paving by Albert Moyer.

International road congress. 2d, Brussels, 1910. Construction of footways in towns, 1910. 625.7 A063i2 v. 3
(Communication, no. 4, in v. 3).

Municipal journal. Practical street construction; planning streets and designing and constructing the details of street surface, subsurface and supersurface structures, reprinted from Municipal journal, during 1916; profusely illustrated with photographs, maps and diagrams. N. Y., 1916. 625.7 M92

Road materials 625.74

Agg, Tansy Radford. American rural highways. N. Y., 1920. 625.7 Ag38

Blanchard, Arthur Horace. Elements of highway engineering. N. Y., 1915. 625.7 B592E

Eno, Frank Harvey. The road building materials of Coshocton County, Ohio, Columbus, O., [1912]. 620 A0720 no. 7
Ohio state university, College of engineering.

International road congress. 2d, Brussels, 1910. Various materials in use for the purposes of construction and maintenance, conditions to be fulfilled, tests, units to be adopted, 1910. 625.7 A063i2 v. 3

International road congress. 2d, Brussels, 1910. Choice of the surfacing materials, 1910. 625.7 A063i2 v. 2

Lovegrove, Edwin James. Attrition tests of road-making stones ...... with petrological description, by John S. Fleet ...... and J. Allen Howe ...... Lond., [1906]. 625.75 L. 94
Glossary of technical terms: p. 71-73.

Purdue university. Laboratory for testing materials ...... Tests of road materials of Indiana, prepared by staff of Laboratory for testing materials. Lafayette, Ind., 1921. 620 A072p no. 7
(Bulletin no. 7, Engineering experiment station).

Sellards, Elias Howard. Roads and road materials of Florida, by E. H. Sellards, H. Gunther, and N. H. Cox. [Saint Augustine], 1911. 557.59 F66b no. 2
(Florida geological survey. Bulletin no. 2.)

Shaler, Nathaniel Southgate. American highways; a popular account of their conditions, and of the means by which they may be bettered. N. Y., 1896. 625.7 Sh1
List of important works on highway construction: p. 292-293.

U. S. Dept. of agriculture. Office of public roads. Bulletin. 625.709 Un3b
CONTENTS: no. 4. Report on road-making materials in Arkansas. By J. C. Branner, 1894.—no. 5. Information regarding road materials and transportation rates in certain states west of the Mississippi River, 1894.—no. 6. Information regarding roads, road materials and freight rates in certain states north of the Ohio River, 1894.—no. 7. Information regarding roads and road-making materials in certain eastern and southern states, 1894.—no. 33. Road materials of southern and eastern Maine. By Henry Leighton and E. S. Bastin, 1908.—no. 37. Examination and classification of rocks for road building, including the physical properties of rocks with reference to their mineral composition and structure. By E. C. E. Lord, 1911.—no. 38. Methods for the examination of bituminous road materials. By Prévost Hubbard and C. S. Reeve, 1911.—no. 40. The road material resources of Minnesota. By G. W. Cooley, 1911.

Specifications 625.74 (003)

British engineering standards association, London. Report on British standard nomenclature of tars, pitches, bitumens and asphalts, when used for road purposes, and British standard specifications for tar and pitch for road purposes. Lond., 1916. (Report no. 76). **620 Aoo3b no. 76**

British engineering standards association, London. Report on British standard specification for sizes of broken stone and chippings. Lond., 1913. (Report no. 63). **620 A003b no. 63**

Ohio. Highway department. General specifications for materials. Columbus, 1914. **625.709 Oh3 no. 25**
(Bulletin of the Ohio highway department. no. 25.)

Ohio. Highway department. General specifications for piers and abutments. Columbus, 1911. **625.709 Oh3g**
With this is bound: Material specifications, no. 4, 1915.

Tests 625.74 (073)

Beckstrand, Elias Hyrum. Tests of macadam rock, by E. H. Beckstrand. Salt Lake City, 1909. **622 A072u no. 2**
(Utah engineering experiment station. Bulletin no. 7.)

Beyer, Samuel Walker. Road and concrete materials of Iowa by S. W. Bayer and H. F. Wright. **557.77 19r5 v. 24**
Contains: Tests and analyses of road materials and directories of stone and gravel producers.
(In Iowa. Geological survey. [Reports and papers.] 1913. v. 24, p. 33-685).

Blanchard, Arthur Horace. Elements of highway engineering. N. Y., 1915. **625.7 B592E**
Contains chapters on Tests of road materials.

California. University. Laboratory experiments; study of adobe soils and concrete slab tests for the California state automobile association and the Automobile club of southern California, as conducted at the University of California, 1921. **625.709 Au8**
(In Automobile club of southern California. The state highways of California, 1921).

International road congress. 3d, London, 1913. Test of materials used in macadamized roads, 1913. **625.7 A063i3 v. 3**

Lovegrove, Edwin James. Attrition tests of road-making stones, with petrological descriptions, by John S. Fleet ...... and J. Allen Howe ...... Lond., [1906]. **625.74 L94**

Nash, James Philip. Road-building materials in Texas, by J. P. Nash and others. Austin, 1918. **622.3 T31 [no. 24]**
(Texas. University. Bureau of economic geology and technology. [no. 24].)

Nash, James Philip. Road materials of Texas. Austin, University of Texas, 1915. **622.3 T31 [no. 7]**
(Texas. University. Bureau of economic geology and technology. [no. 7].)

Schmidt, Hugo. Prüfung von stampfasphalt und anderen strassendecken mit bituminösen bindemitteln, von Hugo Schmidt und Paul Herrmann. Ber., 1915. **625.85 Sc5**

Williams, Walter Scott. An investigation of the road making properties of Missouri stone and gravel, by W. S. Williams ...... and R. Warren Roberts ...... Columbia, Mo., 1911. **620 A072m7 v. 2, no. 3**
(Missouri University. Engineering experiment station. Bulletin v. 2, no. 3.)

Special localities

Canada. Geological survey. Road material surveys in 1914-17. Ottawa, 1916-19 (Memoir, 85, 99, 107, 114.) **557.1 C164m**

Merrill, Frederick James Hamilton. Road materials and road building in N. Y., Albany, 1897. **507.4 N42b no. 17**
(New York state museum. Bulletin vol. 4. no. 17.)

West Virginia. State road bureau. Joint bulletins, comp. by State road bureau, issued by Dept. of agriculture. Charleston, W. Va. **625.7 W52 no. 7**
Study of West Virginia sands.

South Carolina. University. Good roads. Columbia, S. C., 1910. (Bulletin, no. 20). Illus. **625.7 SO8**
Contents: Road building materials, by M. W. Twitchell.

McCallie, Samuel Washington. A preliminary report on the roads and road-building materials of Georgia. Atlanta, 1901. **557.58 G29b no. 8**
(Georgia. Geological survey, 1890—Bulletin no. 8.)

Prouty, William Frederick. Roads and road materials of Alabama. Montgomery, Ala., 1911. **557.61 AL1b no. 11**
(Alabama. Geological survey, 1873- Bulletin no. 11).
Bibliography: p. 126-127.

Lowe, Ephraim Noble. Road-making materials of Mississippi. [Jackson], 1920. **557.62 M69b no. 16**
(Mississippi State geological survey. Bulletin no. 16.)

Nash, James Philip. Road-building materials in Texas, by J. P. Nash and others. Austin, 1918. **622.3 T31 [no. 24]**
(Texas. University. Bureau of economic geology and technology. [no. 24].)

Nash, James Philip. Road materials of Texas. Austin, 1915. 622.3 **T31 [no. 7]**
(Texas. University. Bureau of economic geology and technology. [no. 7]).

[Geology of Arkansas: a collection of pamphlets.] [1890-96.] **557.67 G29**
Contains road-making materials, by J. C. Branner.

Blatchley, Willis Stanley. The roads and road material of Indiana. By W. S. Blatchley and assistants. Indianapolis, 1906. **557.72 In2rn v. 30**
(*In* Indiana. Department of geology and natural resources. Annual report. 1905).

Purdue University. Laboratory for testing materials. ...... Tests of road materials of Indiana, prepared by staff of Laboratory for testing materials. Lafayette, Ind., 1921. 620 **A072p no. 7**
(Bulletin no. 7, Engineering experiment station).

Hotchkiss, William Otis. Limestone road materials of Winconsin, by W. O. Hotchkiss and Edward Steidtmann. Madison, Wis., 1914. **557.75 W75b no. 34**

Beyer, Samuel Walker. Rad and concrete materials of Iowa by S. W. Beyer and H. F. Wright. **557.77 19r5 v. 24**
CONTAINS: Tests and analyses of road materials and directories of stone and gravel producers.
(In Iowa. Geological survey. [Reports and papers.] 1913. v. 24, p. 33-685.)

Oregon. State bureau of mines. Road materials in the Willamette Valley. [2d ed.] [Corvallis, Or.], 1912. (Bulletin no. 1.) 622 **Or3b no. 1a**
"The field observations which form the basis of this report were made by H. M. Parks, assisted by S. W. French and H. E. Cooke."

Landes, Henry. The road materials of Washington. By Henry Landes, assisted by Olaf Stromme and Clyde Grainger. Olympia, Wash., E. L. Boardman, public printer, 1911. **557.97 W27b no. 2**
(Washington (State) Geological survey. Bulletin no. 2.)

Leighton, Morris M. The road building sands and gravels of Washington. Olympia, 1919. **557.97 W27b no. 22**
(Washington, Geological survey Bulletin no. 22.)

Foundations 625.751

International road congress. 2d. Brussels, 1910. Foundations and drainage of roads; methods of carrying out of work. 1910. 625.7 **A063i2 v. 2**

International road congress. 2d, Brussels, 1910. Methods of carrying out road work in connection with water supply. 1910. 625.7 **A063i2 v. 2**

New York (city) Commissioners of accounts. Report on concrete foundations for pavements with special reference to work of that nature in the Borough of Brooklyn, during the year 1902. N. Y., 1903. 625.7 **A009ne8**

Road inspection 625.76

Agg. Tansy Radford. Traffic on Iowa highways. Ames, Ia. [1920]. 620 **A075 no. 56**
(Bulletin 56, Engineering experiment station, Good roads sections.)

Hubbard, Prevost. Highway inspectors' handbook. N. Y., 1919. 625.7 **A02h**

New York (city) Dept. of highways. Instructions to inspectors of street paving. N. Y., 1912? 625.76 **N422**

Winery, Samuel. Specifications for street roadway pavements; with instructions to inspectors on street paving work. Ed. 2, enl. N. Y., 1913. 625.8 **W577s2**

——— ——————— N. Y., 1907. 625.8 **M91**

Maintenance and repair 625.761

Chicago bureau of public efficiency. Repairing asphalt pavement; work done for the city of Chicago under contract in 1911. Chic., 1911. 625.85 **C43**

Codrington, Thomas. Maintenance of macadamized roads. Ed. 2, rev. and enl. Lond., 1892. 625.761 **C64**

[Du Pont de Nemours, E. I., powder company.] Road construction and maintenance. Wilmington, Del., c1915. 625.7 **D928R**

Gearhart, Walter Scott. Highway improvement; construction and maintenance of earth, sand-clay and oiled earth roads, and culverts. Manhattan. Kans., 1910. 625.7 **G26 v. 3**
(Kansas state agricultural college. Agricultural education. v. 3, no. 6).

Judson, William Pierson. Road preservation and dust prevention. N. Y., 1908. 625.7 **J92R**

New Orleans. City engineer. Annual report of operations of the Municipal repair plant, New Orleans, La., 1st-3d; 1906/07-1908/09. New Orleans, 1907-09. 625.761 **N42**
W. J. Hardee, city engineer.

New York (city) Dept. of public works. A repair plant for asphalt pavements for the borough of Manhattan; recommended by George Livingston, commissioner of public works, with an appendix embodying the result of an expert investigation by J. C. Bayles. N. Y., 1903. 625.761 **N43**

U. S. Bureau of public roads. Modern road building and maintenance; principles and practice. Prepared for the use of engineers by A. P. Anderson. n. p., 1920? 625.7 **Un37**
CONTENTS: Planning.—Road materials.—Construction.—Maintenance and repair.—Use of explosives.

Road drag 625.7623

Illinois. Highway commission. Bulletin no. 1-9; 1906-12. Springfield, Ill., 1906-12. 625.709 IL6
no. 1. Earth road drag, how to make it.
no. 2. Road drag law and rules for dragging.

Kentucky. Dept. of public roads. Bulletins, 3-8. Frankfort, Ky., 1912-13. 625.709 K41
no. 5. Split-log drag.

U. S. Dept. of agriculture. Use of the split-log drag on earth roads, by D. Ward King. (Farmers' bulletin 321). Wash., 1908. 625.863 Un33

West Virginia. State road bureau. Joint bulletins, comp. by State road bureau, issued by Dept. of agriculture. Charleston, W. Va. 625.7 W52
no. 3. Road drag.

Surface treatment 625.7624

Aitken, Thomas. Tar-spraying and tar-macadam in situ. Lond., 1913. 625.762 Ai9

California. Department of highways. Oiled roads of California. 625.709 C12
(Bulletin no. 2 (2nd series). Oct., 1904).

Illinois. Highway commission. Surface oiling of earth roads. 1915. 625.709 IL62
(Bulletin [new series] no. 6.)

International road congress. 2d. Brussels, 1910. Metalled and paved roads. 1910. 625.7 A063i2 v. 2

International road congress. 3d, Lond., 1913. Types of surfacing to be adopted on bridges, viaducts, etc. 1913. 625.7 A063i3 v. 1

Smith, Jonah Walker. Dustless roads. Tar macadam; a practical treatise for engineers, surveyors and others, with numerous illustrations and tables. Lond., 1909. 625.863 Sm6

Street cleaning 625.768

Dorr, Clemens. Hausmüll und strassenkehricht. Leipzig, 1912. 628.46 D674H
Literaturverzeichnis: p. 496.

International road congress. 2d, Brussels, 1910. Cleansing and watering [of roads.]; necessity of utility, methods in use, their cost and comparison of various methods, 1910. 625.7 A063i2 v. 2

International road congress. 2d, Brussels, 1910. Removal of snow and ice. 1910. 625.7 A063i2 v. 3

Lefebvre, Georges. Voie publique. Paris, 1896. 625.7 L52
(Bibliothèque du conducteur de travaux publics.)
"Nettoiement, arrosement et enlèvement des neiges et glaces"; p. [424]-485.

New York (city) Board of aldermen. Committee on administration of Dep't of street cleaning. Report on the administration of the Department of street cleaning of the city of New York; adopted by the Board of aldermen, July 10, 1906. N. Y., 1906. 628.46 N42

Ohio. State board of health. Report of a study of the collection and disposal of city wastes in Ohio, 1910. Columbus, O., 1911. 628.4 Oh3
Supplement to the twenty-fifth Annual report of the State board of health ...... 1910.) Report by W. H. Dittoe, assistant engineer. The Studies were carried on under the supervision of Paul Hansen, assistant engineer and acting chief engineer of the Board.

Rochester bureau of municipal research. Report on the problem of street cleaning in the city of Rochester, N. Y.; submitted to the Mayor and to the Commissioner of public works. Rochester, N. Y., 1918. 628.46 R58

Soper, George Albert. Modern methods of street cleaning. N. Y., 1909. 628.46 So65M

Waring, George Edwin, jr. Street-cleaning and the disposal of a city's wastes; methods and results and the effect upon public health, public morals and municipal prosperity. 1899. 628.46 W23

Drainage 625.7682

Baker, Ira Osborn. Drainage of earth roads, by Ira O. Baker ...... [Urbana? Ill.], 1906. 620 A072i no. 2
(Circular no. 2 of the University of Illinois Engineering experiment station.)

International road congress. 2d, Brussels, 1910. Drainage of roads, methods of carrying out of work. 1910. 625.7 A063i2 v. 2

Street lighting. Street signs 625.7688

Bryant, John Myron. Street lighting, by J. M. Bryant and H. G. Hake ...... Urbana, Ill., 1911. 620 A072i2 no. 51

International road congress. 3d, Lond., 1913. Direction and distance of sign posts. 1913. 625.7 A063i3 v. 3

International road congress. 3d, Lond., 1913. Methods of lighting public highways and vehicles. 1913. 625.7 A063i3 v. 2

International road congress. 2d, Brussels, 1910. Road signs; measures taken to carry out the resolutions of the Paris congress. 1910. **625.7 AO63i2 v. 3**

Sugg, William Thomas. Modern street lighting. Ed. 2. Lond., 1887. **625.7688 Su3**

Dust prevention—Binding materials 625.7689

British engineering standards association, London. Report on British standard nomenclature of tars, pitches, bitumens and asphalts, when used for road purposes, and British standard specifications for tar and pitch for road purposes. Lond., 1916. (Report no. 76.) **620 A003b no. 76**

Guglielminetti. Lutte contre la poussière des routes en général et spécialement sur le littoral Méditerranéen; rapport présenté au Congrès de climatothérapie et d'hygiène urbaine, 1907. n. p., 1907? **625.8 P288**

Hubbard, Prevost. Dust preventive and road binders. N. Y., 1910. **625.768 H86**

Illinois. Highway commission. Bulletin no. 6. Springfield, Ill., 1915. **625.709 IL62** no. 6 Dust prevention.

International road congress. 3d, Lond., 1913. Construction of macadamized roads bound with tarry bituminous or asphalt materials. 1913. **625.7 AO63i3 v. 1**

Judson, William Pierson. Road preservation and dust prevention. N. Y., 1908. **625.7 J92R.**

Ohio. Highway department. On dust prevention, 1914. (Bulletin no. 27). **625.709 Oh3 no. 27**

Ohio. Highway department. Report of experiments in binding gravel and crushed gravel with tar and asphalt; also in constructing a water-bound road of gravel. 1910. (Bulletin no. 13). **625.709 Oh3 no. 13**

Ohio. Highway department. Report of experiments to determine the comparative value of road binding materials. 1910. (Bulletin no. 12). **625.709 Oh3 no. 12**

Pennsylvania state college. Engineering experiment station. Bulletin. State college, Pa. **620 A07pe no. 23**
no. 23. Dust prevention on highways, by H. B. Shattuck.

Pittsburgh. Carnegie library. Road dust prevention [a bibliography] 1916. (Monthly bulletin of the Carnegie library of Pittsburgh, v. 21, 1916, p. 148-183). **017.1 P68b v. 21**

Parkways 625.77

New York (state). Bronx parkway commission, New York city. Report, 1st-date, 1914-date. N. Y., 1914-date. **625.77 N42**

Morrison, Ben Y. Street and highway planting. Sacramento, Cal., [n. d.] (California. State board of forestry. Bulletin, no. 4). **634.9 C126 no. 4**

Philadelphia. Fairmont Park art association. Report of the commission ...... to study the entrance of the Philadelphia Parkway into Fairmont Park; as presented at the 36th annual meeting of the Association, Dec. 12th, 1907. Also the address on "Architectural development of cities" delivered by Ralph Adams Cram on the same occasion. Phila., 1908. **710.09 P53**

Pavements 625.8

General

Agg, Tansy Radford. Construction of roads and pavements. N. Y., 1916. **625.7 Ag38c**
Glossary: p. 408-414.

——— ——————— Ed. 2, rev. and enl. N. Y., 1920. Illus., diagrs. **625.7 Ag38c2**
Glossary: p. 442-448.

American asphaltum & rubber co. Open specifications for waterproof macadam roadways, asphaltic concrete pavement, brick and block pavement filler, sheet asphalt pavement, asphalt mastic floors, coating steel pipe, waterproofing reservoirs. Chic., 1911. **625.8 Am3**

Baker, Ira Osborn. A treatise on roads and pavements. 3d ed., re-written and enl. N. Y., 1918. **625.7 B17.3**

——— ——————— Ed. 1, 1903. **625.7 B17**

——— ——————— Ed. 2, 1913. **625.7 B17.2**

Blanchard, Arthur Horace, *ed.* American highway engineers' handbook. N. Y., 1919. **625.7 A02b**
Bibliography at end of each section.

Blanchard, Arthur Horace. Elements of highway engineering. N. Y., 1915. **625.7 B592E**
Contains chapters on Tests of road materials.

Blanchard, Arthur Horace. Text-book on highway engineering, by A. H. Blanchard and H. B. Drowne. N. Y., 1913. **625.7 B592T**

Boulnois, Henry Percy, *comp.* Practical road engineering for the new traffic requirements. Comp. from the special "roads" issues of the Surveyor and municipal and county engineer, Lond., [1910]. **625.7 B66p**

Byrne, Austin Thomas. Treatise on highway construction ...... the location, construction, or maintenance of roads, streets and pavements. Ed. 5, rev. and enl. N. Y., 1908. 625.7 B99a
Authors and publications referred to: pref. 5-8.

——— ——————— Ed. 4, rev. and enl. N. Y., 1900. 625.7 B99
Library also has the following editions:
Ed. 3, rev. and enl. 1896.
Ed. 2, rev. and enl. 1893.
1892.

Chatburn, George Richard. Highway engineering, rural roads and pavements. N. Y., 1921. (Wiley agricultural engineering series.) 625.7 C39
Bibliography: p. iv-vi.

Chicago. Commission on city expenditures. Preliminary report on street paving. Chic., 1910. 625.7 C43
The following are bound with this: Street pavements laid in Chicago, by the Chicago bureau of public efficiency.—Pavements recently built, by the Chicago Board of local improvements.

Clark, Daniel Kinnear. The construction of roads and streets. Lond., 1877. 625.7 C54
pt. 1 The art of constructing common roads, by Henry Law; rev. and oondensed by D. K. Clark.
pt. 2 Recent practice in the construction of roads and streets, including pavements of stone, wood, and asphalte, by D. K. Clark.

Collier, H. L. Street pavements for Atlanta. Atlanta, [1906?]. 625.8 C69

Durham, Henry Welles. Street paving and maintenance in European cities; a report by Henry Welles Durham, chief engineer of the Bureau of highways, December 31, 1913. [N. Y., 1914]. 625.8 D93
The results of a study of paving and pavement maintenance conditions in the leading cities of Europe, made on a trip undertaken for that purpose by direction of the late mayor of New York (W. J. Gaynor).

Frost, Harwood. The art of roadmaking, treating of the various problems and operations in the construction and maintenance of roads, streets, and pavements, written in non-technical language. N. Y., 1910. 625.7 F92
"Bibliography of roads, streets, and pavements": p. 505-533.

Gillette, Halbert Powers. Economics of road construction. Ed. 2, enl. N. Y., 1906. 625.7 G413E2

——— ——————— N. Y., 1901. 625.7 G413E

Gillmore, Quincy Adams. Practical treatise on roads, streets, and pavements. N. Y., 1876. 625.7 G417p

——————— same. Ed. 6. N. Y., 1888. 625.7 G417p.2

Grant, William Harrison. Roads and walks of Central park in the city of New York; being a description of their mode of construction, etc., adapted to general application in making public and private roads and walks. 1865. 625.8 G76

Hartford, Conn. Common council. Report of the Special committee appointed by the Common council to investigate the subject of street pavements. Hartford, 1869. 625.8 L84r

Highways green book. 1st; 1920. Wash., 1920. 625.7 H53
Contains bibliographies.

Howard, James Wardell. Well paved streets; their importance, economy, materials and administration. N. Y., 189—? 625.8 H83
(Municipal program leaflet, no. 3.)
Address at the joint conference on municipal government and improvement.

International road congress. 2d, Brussels, 1910. Highway engineering, by Arthur H. Blanchard ...... and Henry B. Drowne ...... N. Y., 1911. 625.7 In8

Judson, William Pierson. City roads and pavements suited to cities of moderate size. 2d ed., rev. and enl. N. Y., 1902. 625.7 J92a

——— ——————— Ed. 3, rev. N. Y., c1906. 625.7 J92a3

Judson, William Pierson. City roads and pavements suited to Oswego, N. Y. Oswego, 1894. 625.8 J92
Not limited to Oswego.

Lefebvre, Georges. Voie publique. Paris, 1896. (Bibliothèque du conducteur de travaux publics). 625.7 L52

London. Metropolitan board of works. Reports by the engineer of the Board and the engineer to the City commission of sewers on the use of asphalte for paving purposes. Lond., 1871. 625.8 L84r
Report by William Haywood.

London. Commissioners of sewers. Report on the accidents to horses on carriageway pavements; by William Haywood. Lond., 1873. 625.8 L84
NOTE: Fifty days observation of asphalt, granite and wood pavement to determine cause and per-centage of accidents.

London. Commissioners of sewers. Report to the commissioners upon the comparative durabilities of granite and wood carriageway pavings; by William Haywood. Lond., 1853. 625.8 L84r

London. Commissioners of sewers. Report to the commissioners upon the experimental carriage-way pavements in Moorgate street, by William Haywood. Lond., 1857. 625.8 L84r

[Love, Edward G.] comp. Pavements and roads; their construction and maintenance. Reprinted from the Engineering and building record. N. Y., 1890. 625.8 L94

CONTENTS: pt. I. Stone pavements. Wood pavements. Asphalt pavements. Brick pavements. Curbs, sidewalks and tramways. Street opening, maintenance. Notes.—pt. II. Roads: Construction and maintenance.—pt. III. Prize essays on road construction and maintenance, submitted in the competition instituted by the Engineering and building record. Report of Committee of award.

Morales y Pedroso, Luis. El sistema de alcantarillado y pavimentacion de la ciudad de la Habana. (Conferencias leidas en la Sociedad cubana de ingenieros), 1916. Habana, 1916. 628.209 M79

At head of title: Revista de la Sociedad cubana de ingenieros.

Morrison, Charles Edward. Highway engineering, N. Y., 1908. 625.7M83

"The following pages were prepared for the second-year students of the Department of civil engineering at Columbia university."—Pref.

Mullen, Charles Augustine. Paving economy, road and street. Montreal, 1917. 625.8 M91

The following are bound with this: Good pavements on streets, by J. W. Howard.—Asphalt pavements, by Kansas city testing laboratory.—Pavement guaranties, by J. W. Howard.—Specifications for street roadway pavements, by S. Whinery.—Portland cement concrete roads, by J. W. Howard.—Granite pavements, by Venable bros.—Paving problem, by J. W. Howard.

New York (city). Dept. of public works. Article on street pavements. N. Y., 1891. 625.8 N42

Thomas F. Gilroy, Commissioner of public works.
Most of this material appeared in the Report of the Dept. for the quarter ending Dec. 31, 1890.

Ontario. Department of public highways. Report on street improvement, Ontario, 1917. Toronto, 1917. 625.709 On8

Our roadways; remarks addressed to the Commissioners of sewers, the Metropolitan board of works, municipal corporations, members of vestries, and local boards, by Viator. Lond., 1876. 625.8 Ou7

[Pavements; a collection of pamphlets made up of various city documents.] 1868-1914. CONTENTS: Cementing power of road materials.—Control of street openings.—Montreal.—Cleveland.—Philadelphia.—Akron pavements.—Willimantic.—Birmingham.—Buenos Aires.—Baltimore. 625.8 P28

[Pavements; a collection of pamphlets on roads and pavements.] 625.8 P28c

CONTENTS: Avondale, Ohio.—Detroit.—Washington, D. C.—Georgia.—Essex County, N. Y.

Paxton, Edward Thurber. *ed.* Street paving in Texas. Austin, Tex., 1915. (Bulletin of the University of Texas. 1915; no. 26. May 5, 1915. ...... Municipal research ser. no. 93. 625.709 P28

"Street paving in Texas [by L. W. Kemp]": p. [10]-17.

Pittsburgh. City councils. Report by a special committee of their bodies appointed to visit St. Louis, Chicago, and other cities to obtain reliable information concerning the Nicolson pavement. n. p. 1867? 625.8 L84r

Roads and pavements. Austin, Tex., 1917. (University of Texas bulletin. no. 1735: June 20, 1917.) 625.7 R53

Papers presented at a meeting held at the University of Texas, 1917.
CONTENTS: Concrete roads, by A. W. Bowles.—Asphalts and tars in surface treatments, by R. G. Tyler.—Penetration bituminous pavements, by R. G. Tyler.—A discussion of road materials, by J. P. Nash.

Roads and pavements; papers presented before the short course in highway engineering held at the University of Texas, March 31-April 12, 1919, under the auspices of the Department of engineering. Austin, Tex., 1919. (University of Texas bulletin, no. 1922: April 15, 1919). 625.7 R53

CONTENTS: Earth roads, by R. G. Tyler.—The preparation of road plans involving state or federal aid, by M. C. Welborn.—Drainage areas and culverts, by G. G. Wickline.—Preparation of specifications and contracts, by R. G. Tyler.—Road surfaces, by J. D. Fauntleroy.—Bituminated roads, by M. C. Welborn.—Penetration bituminous pavements, by R. G. Tyler.—Trap rock as the mineral aggregate in hard-surfaced roads and streets, by A. H. Muir and E. L. Dennis, jr.,—Concrete construction, by J. Montgomery.

[Roads and pavements of New York; a collection of pamphlets.] 1876-1911. Contents: State highways, by Good roads commttee of the Board of supervisors of Monroe county.—Pavement question, by City engineer of Syracuse.—Report on pavements by the City engineer of Canandaigua. Report of investigation of proposed pavements for East avenue, by City engineer of Rochester.—Pavements in the city of Binghamton, by the Binghamton chamber of commerce.—Construction and repair of sidewalks, curbs and gutters, by Poughkepsie Board of public works.—Maintenance of pavements and administration of streets in the city of New York, by the Merchants Association of New York.—Table showing length of streets regulated and graded (in New York city) from 1871 to 1898, —Report on the twenty-third and twenty-fourth wards, by the New York city Dept. of public works.—Improvement of the street pavements in the business part of the city, by the New York Chamber of Commerce.—Street pavements, by the Grahamite and Trinidad asphalt pavement company. 625.709 R531

Rockwell, Alfred Perkins. Roads and pavements in France. N. Y., 1896. 625.7 R59

Spalding, Frederick Putnam. Text-book on roads and pavements. Ed. 4. rev. and enl. N. Y., 1912. 625.7 Spla4

—— —— Ed. 3, rev. and enl. N. Y., 1908. 625.7Spla3

—— —— Ed. 1. N. Y., 1894. 625.7 Spl

Tillson, George William. Street pavements and paving materials. A manual of city pavements; the methods and materials of their construction. 2d ed. N. Y., 1912 625.8 T46a

——— ——————— N. Y., 1900. 625.8 T46

Specifications 625.8 (003)

Association for standardizing paving specifications. Annual report ...... Proceedings. 1st-4th, 1910-13. [Chic., 1910-13.] 625.8 A003a
Prior to March, 1911, the name of the society was Organization of city officials for standardizing paving specifications. In 1913 the Association merged with the American society of municipal improvements.
No more published.

Boston. Street dept. [Contract and specifications for pavements. 1891-1893.] 625.8 A003b
CONTENTS: Furnishing paving bricks.—Large paving blocks.—North-river flagging.—Furnishing crushed stone to the city crushers.—Teaming crushed stone.—Repairing asphalt pavements for the city of Boston.—Surfacing drives and walks on the parkway between Tremont and Perkins streets.—Laying a brick wall at Charlesbank.
The last two were issued by the Dept. of parks.

[Contracts and specifications for brick pavements. 1890-1902]. 625.8 A003s4
CONTENTS: Marion, Ind.—Jackson, Miss.—La Porte, Ind.—Sioux City, Ia.—Lock Haven, Pa.—Alexandra, Ind.

[Contracts and specifications for paving with brick.] 625.87 C76
Includes the following cities: Newark, N. J.—Brooklyn.—Albany.—Marion, Ind.

France. Departement de la Seine. Devis et cahier des charges de l'entreprise des travaux d'entretien et de construction des trottoirs et dallages en granit, lave et pavés, et des urinoirs appliques dépendant du Service municipal des travaux publics de Paris, du Ier janvier, 1878, au 31 décembre, 1882. Paris, 1877. 625.709 F84

France. Departement de la Seine. Devis de fournitures de pavés neufs à faire du ler octobre, 1876, au 31 décembre, 1880, pour les voies publiques de Paris. Paris, 1876. 625.709 F84

Hanson, Edward Smith. Concrete roads and pavements. Rev. ed. Chic., 1914. 625.8 H198c2

——— ——————— Chic., 1913. 625.8 H198c

Howard, James Wardwell. Standard specifications for creosoted wood block pavement. N. Y., 1910. 625.8 A003h
Bound with this are specifications for cedar block pavement for Detroit, and granite block pavements for Washington and Louisville.

Kent, England. County council. Experimental sections of concrete roads laid by the Kent county council under arrangement with the Road board. Maidstone, 1914. 625.8 A003k

Louisville, Ky. City engineer. Specifications for pavements, 1886-1896. 625.8 A003Lo
Specifications cover street repairs, granite streets, asphalt streets, vitrified brick or blocks.

Lynchburg, Va. City engineer. Standard specifications for the construction of improved pavements and appurtenances. Lynchburg, Va., 1912. 625.8 A003Ly
H. L. Shaner, city engineer.

New York (state). Commission of highways. Specifications for types of roads and pavements and materials of construction used therein to be used by the New York state highway department, recommended by A. H. Blanchard and P. Hubbard to New York state department of efficiency and economy, Dec. 4, 1913. Albany, 1913. 625.709 N42s
This is also contained in the Report of the N. Y. (state) Dept. of efficiency and economy for 1915 (625.709 N421h).

New York (state) Dept. of efficiency and economy. Annual report concerning matters relating to the construction and maintenance of public highways, 1915. Albany, 1915. 625.709 N421h
Apx. 5-8 contain Specifications recommended to the Highway dept., Dec. 4, 1913.—Highway commission specification for bituminous material A, discussed at conference on Jan. 6, 1914.—Specifications adopted Jan. 15, 1914 for top course bituminous macadam.—New specifications recommended by Advisory board.

New York (city) Dept. of public works. Contract for regulating and paving, with Hamar wood preserved pavement, the carriage-way of Fifth Avenue, from 124th to 130th streets, 1870. 625.8 A003nw

New York (city) Queens borough, Bureau of highways. Contract, including notice to contractors, bid or proposal, contract, bonds, certificates, and specifications, for regulating, grading, curbing, and paving with asphalt blocks on a concrete foundation, together with all work incidental thereto. N. Y., 1908. 625.8 A003nb

New York (city) Bureau of highways. Repaving work; proposals for bids or estimates, bid or estimate, bond, contract and specifications. 1912-13. 625.8 A003nr
CONTENTS: For repaving with rock asphalt on a concrete foundation.—For repaving with wood block on a concrete foundation.—For repaving with sheet asphalt, heavy traffic mixture, with Portland cement filler and close binder on a concrete foundation.

New York (city) Dept. of public works. Proposals for regulating and paving with asphalt pavement on concrete foundation. N. Y., 18—. 625.8 A003np
Also Proposals for regulating and paving with asphalt on the present (189—) pavement.

New York (city) Dept. of public works. Specifications and proposals [for paving N. Y. streets with granite, or trap-block pavement 1875-88]. 625.82 N42
A collection of specifications bound in one volume.

New York (city) Dept. of public works. Specifications for regulating and paving with macadamized pavement. 1876-81. 625.8 A003ns
CONTENTS: Fifth ave. from 19th st. to 110th st.—Broadway in the 24th ward.—Riverside ave. between 72nd st. and 130th st.

Queens County (N. Y.) Board of supervisors. Proposals [and specifications] for grading regulating, and macadamizing the public highway, in the town of Jamaica, known as Locust avenue. Jamaica, 1892. 625.8A003q

Richmond County, N. Y. Engineer of roads. Specifications for macadam pavement. West New Brighton, 1890. 625.8 A003r
Henry P. Morrison, Engineer of county roads.

[Specifications for asphalt pavements.] Contents: For asphalt street wearing surface, Los Angeles, 1897.—For reconstructing streets with asphalt, Louisville, Ky.—Specifications for asphaltum pavements, District of Columbia, 1878.—For sheet asphaltum, brick and stone, Omaha, Neb., 1897.—For concrete road construction, Illinois, 1913. 625.8 A003s5

[Specifications for macadam roads.] Contents: Telford road between Western and Central avenues, Albany.—Gravel road from Hammonton to Absecon, N. J.—For macadam road, Birmingham, Eng.—For macadamizing Flushing and N. Hempstead turnpike.—For the construction of Green township [Ohio] free turnpike.—For water-bound macadam, Illinois. —For bituminous macadam, Illinois.—For a stone road in—county, N. J.—For grading and laying macadam, St. Louis.—For construction of parkways, Wilmington, Del.—Specifications for Telford pavement.—For roads, etc. at Fort Wayne, Mich.—For paving through the township of Summit, N. J. 625.7 A003s.

Whinery, Samuel. Specifications for street roadway pavements; with instructions to inspectors on street paving work. Ed. 2, enl. N. Y., 1913. 625.8 W577s2

Good roads year book. [1912]-16. Wash. The American highway association, 1912-1. 625.7 G59
1912-15 have title: The Official good roads year book of the United Stated.
Contains bibliographies.
Most of the vols. contain "State road legislation", Patents issued, and Directories of road contractors.

Patents 625.8 (008)

Municipal powers; the right of cities to purchase patented articles sustained by the highest courts; extracts from decisions rendered on this question; the meaning of charter provisions requiring competitive bidding defined. Bost., 1907? 625.8 A008m
Opinions as to the legality of laying bitulithic pavement (patented by the Warren Brothers Co.)
Includes list of cases deciding contracts for pavements to be valid.

Sinsabaugh, L. W. Digest of United States patents for paving and roofing compositions, to Jan. 1, 1875, and English paving compositions, to January 1, 1874. Wash., 1875. 625.8 A008s

Warren brothers co. *vs.* **City of Owosso.** Opinion of court, in the United States circuit court of appeals, sixth circuit. Chic., 1909. 625.8 008m
Bitulithic patents held valid by Court of last resort; Barber asphalt paving co. found guilty of infringement.
Bound with other pamphlets.

Congresses 625.8 (063)

See Congresses under Roads

Tests 625.8 (073)

Philadelphia. Bureau of highways and street cleaning. Report on service test road, Byberry and Bensalem turnpike. Phila., 1913. 625.8 P53

Sydney, New South Wales. City surveyor. Test of metals [for road pavements] used in Sydney; report presented to the Works committee, Aug. 1903. Sydney, 1903. 625.861 Sy2

Special pavements

Stone 625.82

France. Departement de la Seine. Devis et cahier des charges de l'entreprise des travaux d'entretien et de construction des trottoirs et dallages en granit, lave et pavés, et des urinoirs appliques dépendant du Service municipal des travaux publics de Paris, du 1er janvier, 1878, au 31 décembre, 1882. Paris, 1877. 625.709 F84

France. Departement de la Seine. Devis de fournitures de pavés neufs à faire du 1er octobre, 1876. au 31 décembre, 1880, pour les voies publiques de Paris. Paris, 1876. 625.709 F84

International road congress. 3d, Lond., 1913. Various types of stone paving in use. 1913. 625.7 A063I3 v. 3

London. Commissioners of sewers. Report to the commissioners upon the comparative durabilities of granite and wood carriage-way pavings; by William Haywood. Lond., 1853. 625.8 L84r
With this are bound other pamphlets on paving.

London. Commissioners of sewers. Report to the Streets committee upon granite and asphalte pavements, by William Haywood. Lond., 1871. 625.82 L84

Louisville, Ky. City engineer. Specifications for pavements, 1886-1896. 625.8 A003Lo
Specifications cover street repairs, granite streets, asphalt streets, vitrified brick or blocks.

New York (city) Dept. of public works. Specifications and proposals [for paving N. Y. streets with granite, or trap-block pavement, 1875-88]. 625.82 N42
A collection of specifications bound in one volume.

Wood 625.83

Bell, George W. Street-paving in Sydney [wood pavements]. Sydney, 1895. 625.83 B41

Cincinnati, Ohio. Bureau of Municipal research. Reports. 1910-11. Cincinnati, 1910-11. 352 A072c
CONTENTS:
no. 1. Paving report no. 1, relating to wood block paving contracts.
no. 2. Reply of Director of Public service to Paving report no. 1.
no. 3. Paving report no. 2: The Reading road contract wood block paving.
no. 4. Wanting.
no. 6. Paving report no. 5: What is being done on Reading road.

Geddes, George. Observations upon plank roads, together with the general plank road law of the state of New York, as amended by the laws of 1847, 1848, 1849 and 1850. Syracuse, N. Y., 1850. 625.83 G26

Hamar wood preserved pavement co. Prospectus. N. Y., 1870. 625.83 H17

Haywood, William. Report to the Commissioner of sewers of London upon asphalte and wood pavements. Lond., 1874. 625.83 H38

——— ——— Report to the street committee, Feb. 1, 1877. Lond., 1877.
Other pamphlets are bound with this.

Howard, James Wardwell. Standard specifications for creosoted wood block pavement. N. Y., 1910. 625.8 A003h
Bound with this are specifications for cedar block pavement for Detroit, and granite block pavements for Washington and Louisville.

Improved wood pavement co., ltd. Prospectus. Lond., n. d. 625.83 H33

International road congress. 3d, London, 1913. Wood paving, 1913. 625.7 A06313 v. 2.

Johnson, Frank G. Nicolson pavement, and pavements generally. N. Y., W. C. Rogers, co., 1867. 625.8 L84r

Kingsford, William. History, structure and statistics of plank roads, in the United States and Canada; with remarks on roads in general by F. G. Skinner; and a letter on plank roads by Charles E. Clarke. Phil., 1851. 625.83 K61

Kummer, Frederic Arnold. Creo-resinate wood pavements for streets and bridges. N. Y., 1903. 625.83 K96

Kummer, Frederic Arnold. Modern wood pavements, creo-resinate process, including a paper on recent experiences with wood pavements by B. T. Wheeler. N. Y., 1901. 625.83 K96m

Mountain, Adrien Charles. Wood-paving in Australia; its origin and subsequent development. Melbourne, 1897. 625.83 M86

New York (city) Board of estimate and apportionment. Translation of papers by P. Tur on asphalt and wood pavements in the City of Paris, and by Louis Mazerolle on the the requisite qualities of wood for pavements. N. Y., 1909. 625.85 N42

New York (city) Bureau of highways. Proposals for bids or estimates, bond, contract and specifications for regulating and repaving with wood block pavement on a concrete foundation. N. Y., 1913. 625.8 A003nr

New York (city) Dept of public works. Contract for regulating and paving, with Hamar wood preserved pavement, the carriage-way of Fifth Avenue, from 124th to 130th streets. 1870. 625.8 A003nw

Newark, N. J.—Mayor. Veto and message against wood block pavement for Broad Street, Newark, N. J., including the report of the consulting engineer. Newark, 1913. 625.83 H33

Northwestern Stafford pavement co. Wooden pavements; their utility in the streets of large cities and general advantages of the Stafford pavement. n. p., 1869. 625.83 H33

Ream combination sectional wooden pavement co. Prospectus. N. Y., 1870. 625.83 H33

[Woodblock pavement; a collection of pamphlets. 1894-1911.] 625.83 W85
CONTENTS: Preliminary discussion on creosoted wood block pavement, by C. M. Taylor.—On Australian hard woods for London pavements, by W. A. Smith.—Report on creosoted wood-block pavements, by John Ericson.

Concrete 625.84

Agg, Tansy Radford. An investigation of concrete roadways, by T. R. Agg and C. B. McCullough ... Ames, Ia., 1916. q625.84 Ag3

Association of American portland cement manufacturers. Concrete country road built by the state department of Public roads of New Jersey. Phila., n. d. 666.942 As7

Association of American portland cement manufacturers. Concrete highways. Phila., 1912-15. 625.84 A78

Three pamphlets issued by the association covering general construction, specifications, etc. and tabular digest of some concrete pavements of which records are at hand.

Association of American portland cement manufacturers. Facts everyone should know about concrete roads. Phila., n. d. 666.942 As7

Automobile club of southern California. The state highways of California; an engineering study conducted jointly by the Automobile club of southern California and the California state automobile association, July, 1920-January, 1921. [Los Angeles, c1921]. 625.709 Au8

Issued also with different arrangement of text and with sub-title: An engineering study conducted jointly by the California state automobile association and the Automobile club of southern California.

Brittan, S. B. Pavement question considered; Scrimshaws' concrete pavement preferred: the respective claims of different pavements examined; their merits and defects freely discussed and exposed. Newark, 1869. 625.84 B77

Hanson, Edward Smith. Concrete roads and pavements. Rev. ed. Chic., 1914. 625.8 H198c2

Appendix on Specifications.

——— ——————— Chic., 1913. 625.8 H198c

Hatt, William Kendrick. Concrete work; by William Kendrick Hatt ...... and Walter C. Voss ...... N. Y., 1921. 693.5 H28

2 v. Contains chapter on concrete walks and pavings.

Kent, England. Country council. Experimental sections of concrete roads laid by the Kent county council under arrangement with the Road board. Maidstone, 1914. 625.8 A003k

Leverich, Gabriel. Treatise on the Excelsior pavement and others of bituminous concrete. N. Y., 1871? 625.84. L57

This library also has a photostat copy of this pamphlet, (cop. 2).

National conference on concrete road building. Proceedings. 1st-2d; 1914-1916. Chic., [c1914]- 1916. 625.84 A063n

National lime manufacturers' association, Pittsburgh, Pa. Improving concrete roads, the effect of hydrated lime on permeability, expansion and contraction. Pittsburgh, 1916. 625.84 N21

Portland cement association, Chicago. Concrete feeding floors, barnyard pavements and concrete walks. Chic., 1916. 693.5 P83c

Portland cement association, Chicago. Concrete facts about concrete roads ...... Chic., 1917. 625.84 P83c

Portland cement association, Chicago. Protecting concrete work done in warm weather. Chic., 1917. 693.5 P83p

Shoop, Charles Franklin. Investigation of the concrete road-making properties of Minnesota stone and gravel. Minneapolis, 1915. (Minnesota university. Studies in engineering. No. 2.) 620 A072m5 no. 2

[Thompson, Sanford Eleazer.] Concrete in highway construction, a text-book for highway engineers and supervisors ...... N. Y., [1909]. 666.993 T37

Asphalt 625.85

Abbott, N. B. Bituminous concrete pavements as laid in the United States. Ed. 2. Brooklyn, 1876. 625.85 Ab2

[Asphalt; a collection of pamphlets.] 1871-1902. 625.85 As6

Boorman, Thomas Hugh. Asphalts, their sources and utilizations, 1914 road ed., containing five new chapters on modern road construction, by T. Hugh Boorman ...... N. Y., 1914. 665.45 B64a

——— ——————— N. Y., 1908. 665.45 B64

Chicago bureau of public efficiency. Repairing asphalt pavement; work done for the city of Chicago under contract in 1911. Chic., 1911. 625.85 C43

Delano, William Henry. Twenty years' practical experience of natural asphalt and mineral bitumen. Lond., 1893. 665.45 D37

France. Departement de la Seine. Municipal service of works in Paris; detailed price list and prescribed charges for the construction and maintenance of footpaths and pavements in bitumen and of the areas and roads in compressed asphalt belonging to the municipal service from the 1st January, 1872 to the 31st December, 1877. Paris, 1872. 625.709 F84

Halleck, Henry Wager. *comp.* Bitumen; its varieties, properties, and uses. Wash., 1841. 665.45 H15

(Half-title: Papers on practical engineering. Published by the Engineer department.)

Haywood, William. Report to the Commissioner of sewers of London upon asphalte and wood pavements. Lond., 1874. 625.83 H33

——— ——————— Report to the street committee, Feb. 1, 1877. Lond., 1877.

Hubbard, Prevost. Laboratory manual of bituminous materials for the use of students in highway engineering. N. Y., 1916. **625.8 H862L**
Important definitions: p. 2-7

London. Commissioners of sewers. Report to the Streets committee upon granite and asphalte pavements by William Haywood. Lond., 1871. **625.82 L84**

London. Metropolitan board of works. Reports by the engineer of the Board and the engineer to the City commission of sewers on the use of asphalte for paving purposes. Lond., 1871. **625.8 L84r**
Report by William Haywood.

Louisville, Ky. City engineer. Specifications for pavements, 1886-1896. **625.8 A003Lo**
Specifications cover street repairs, granite streets, asphalt streets, vitrified brick or blocks.

Malo, Leon. L'asphalte, son origine, sa préparation, ses applications; 2 éd. entièrement refondue et misc au courant des derniers perfectionnements de l'industrie de l'asphalte. Paris, 1888. **665.45 M29a**

New York (city) Board of estimate and apportionment. Translation of papers by P. Tur on asphalt and wood pavements in the City of Paris, and by Louis Mazerolle on the requisite qualities of wood for pavements. N. Y., 1909. **625.85 N42**

New York (city) Bronx borough. Public works commission. Report on White Plains road experimental pavements, by W. H. Connell. N. Y., 1911. **625.7 N42**
v. 2 consists of Photographs of cross sections of the White Plains road experimental pavements.

New York (city) Bureau of highways. Proposals for bids or estimates, bid or estimate, bond, contract and specifications for regulating and repaving with sheet asphalt, heavy traffic mixture, with Portland cement filler and close binder on a concrete foundation. N. Y., 1913. **625.8 A003nr**

New York (city) Commissioners of accounts. Asphalt paving. N. Y., 1904. **625.809 N42**
Signed: John C. Hertle, William Harman Black, commissioners of accounts.
"Reproduction of the Report of an investigation of asphalt paving, dated May 9, 1899": p. [165]-224.

New York (city) Dept. of public works. Report on street pavements with special reference to asphalt pavements, 1892. N. Y., 1892. **625.85 N43**
An extract from the Report of the dept. for 1891.

New York (city) Queens borough. Bureau of highways. Contract, including notice to contractors, bid or proposal, contract, bonds, certificates, and specifications, for regulating, grading, curbing, and paving with asphalt blocks on a concrete foundation, together with all work incidental thereto. N. Y., 1908. **625.8 A003nb**

Peckham, Stephen Farnum. Solid bitumens, their physical and chemical properties and chemical analysis; together with a treatise on the chemical technology of bituminous pavements. N. Y., 1909. **665.45 P33**

Richardson, Clifford. Asphalt construction for pavements and highways; a pocketbook for engineers, contractors and inspectors. N. Y., 1913. **625.8 R393A**

Richardson, Clifford. Modern asphalt pavement. Ed. 2, rev. and enl. N. Y., 1908. **625.85 R41a**

——— ——————— Ed. 1. N. Y., 1905. **625.85 R41**

Richardson, Clifford. On the nature and origin of asphalt. Long Island City. 1898. **625.85 R41n**
(Barber asphalt paving company. Contributions to the chemistry of the natural hydrocarbons and their derivatives. no. 1.)
Reprinted, with additions, from the Society of chemical industry. Jan., 1898.

Richardson, Clifford. [Papers on asphalt and asphalt pavements.] 1912-1917. **665.45 R39a**
Mostly reprints from technical serials.
Also a pamphlet by E. C. Pailler: The differentiation of natural and oil asphalts.

——— ——————— 1897-1913. **665.45 R39**

Schmidt, Hugo. Prüfung von stampfasphalt und anderen strassendecken mit bituminösen bindemitteln, von Hugo Schmidt und Paul Herrmann. Berlin, 1915. **625.85 Sc5**

[Specifications for asphalt pavements.] **625.8 A003s5**
CONTENTS: For asphalt street wearing surface, Los Angeles, 1897.—For reconstructing streets with asphalt, Louisville, Ky.—Specifications for asphaltum pavements, District of Columbia, 1878.—For sheet asphaltum, brick and stone, Omaha, Neb., 1897.—For concrete road construction, Illinois, 1913.

Tipper, Harry. Testing asphalt. n. p. 1909? **665.54 T51**

[Trinidad asphalt pavements; a collection of pamphlets 1888-93.] **625.85 T73**
CONTENTS: Trinidad asphalt all the same whether lake, land or overflow.—Can [it] be laid in Cleveland.—Trinidad asphalt sheet-pavement.—Lake and land Trinidad asphalt, N. Y.—The lake and land asphalts of Trinidad, Lond., 1893.—The coming pavement, variously known as the "American", "Grahamite", "Trinidad" (De Smedt patents).—La Fortunée Trinidad asphalt, 1894.

Val-de-Travers asphalt paving co., ltd., London. List of works [done by the company]. Lond., 1883. **625.85 V23**
The following are bound with this: Asphalt pavements, sheet vs. block.—Asphaltic rocks of the U. S. and their use in street paving, by S. F. Peckham.

Brick 625.861

Baker, Ira Osborn. Durability of brick pavements. Indianapolis, c1891. 625.861 B17
The following are bound with this: Statistics about brick pavements in various cities, by H. N. Ruttan.—Brick pavements by Warren-Schraft asphalt paving co.—Brick as au experimental paving material.—Correspondence on paper on brick pavements between F. A. Calkins and I. O. Baker.

Blair, Marion W. A study of the rattler test for paving brick, by M. W. Blair and Edward Orton, jr. ...... Columbus, O., 1911. (Bulletin no. 3, College of engineering.) 620 A072o no. 3
Authorized reprint from the Proceedings of the American society for testing materials, Philadelphia, vol. xi, 1911.

[Contracts and specifications for brick pavements. 1890-1902.] 625.8 A003s4
Contents: Marion, Ind.—Jackson, Miss.—La Porte, Ind.—Sioux City, Ia.—Lock Haven, Pa.—Alexandria, Ind.

[Contracts and specifications for paving with brick.] 625.861 C76
Includes the following cities:—Newark, N. J.—Brooklyn.—Albany.—Marion, Ind.

Interstate vitrified brick and paving company, Phil., *pub.* Brick roadways. Phil., 1894. 666.71 A085i

Iowa engineering society. Brick paving in Iowa; report of the Brick paving committee [of the society]. Chic., 1902. 625.861 Io9
Presented at the annual meeting, 1902.

Kummer, Frederic Arnold. Vitrified brick for street pavements; a description of its manufacture and some notes on its use. Catskill, N. Y., 1899. 666.71 K96

Louisville, Ky. City engineer. Specifications for pavements, 1886-1896. 625.8 A003Lo
Specifications cover street repairs, granite streets, asphalt streets, vitrified brick or blocks.

Mandigo, Clark R. A text book on brick pavements. Kansas City, Mo., 1917. 625.861 M31

National brick manufacturers' association of the United States of America. Report of the Commission appointed to investigate the subject of paving brick tests and to recommend standard methods for their conduct. Indianapolis, 1897. 666.71 N21

National paving brick manufacturers' association. Specifications for standard rattler tests for paving brick endorsed and recommended by the association; a report of the Committee on technical investigation, adopted at Louisville, Feb. 7, 1911. 666.71 N21

National paving brick manufacturers' association. Specifications for the construction of vitrified brick street pavements. Cleveland, 1916. 625.861 N21
Contents: Sand-cement superfoundation type, cement grout filler.—Green concrete foundation type, cement grout filler.—Sand cushion type, sand and bituminous joint fillers.

National paving brick manufacturers' association. Specifications for the construction of vitrified brick street pavements and vitrified brick highways. Cleveland, O., 1914. 625.861 N21s
The following are bound with this: Directions for laying vitrified brick street pavements.—Paving brick, the necessity of uniform quality, by J. W. Howard.

Orton, Edward. Some observations on the qualities of paving bricks. Columbus, O., 1911. (Bulletin no. 1, College of engineering.) 620 A072o no. 1
Reprint from Transactions American ceramic society, vol. xiii.

Wallace, W W , jr. Brick pavements, Willoughby, O., 1895. 625.861 W14

Wheeler, Herbert Allen. Vitrified paving brick; a review of present practice in the manufacture, testing and uses of vitrified paving brick. [2d ed.] Indianapolis, Ind., 1910. 666.71 W56

Gravel—Crushed stone 625.862

Agg, Tansy Radford. Investigations of gravel for road surfacing. Ames, Ia., Iowa state college of agriculture and mechanic arts [1916]. (Bulletin 45, Engineering experiment station, Good roads section.) 620 A072i5 no. 45

Rogers, Frank F. Gravel roads, Ed. 2. Lansing, 1913. (Michigan. State highway dept. Bulletin no. 2.) 625.862 625.709 M58

Washington (state) Special investigating commission on Highway department. Report of Special investigating commission on Highway department. Report of the Board of control on state rock-crushing plants: working convicts on state roads and at crushing plants. Financial statement of the state rock-crushing plants. Olympia, 1910. 625.7 W27
Chairman: H. P. Gillette.
Chairman of Board of control: A. E. Cagwin.

Macadam 625.8632

Codrington, Thomas. Maintenance of macadamized roads. Ed. 2, rev. and enl. Lond., 1892. 625.761 C64

McAdam, John Loudon. Remarks on the present system of road-making, with a view to a revision of the existing laws and the introduction of improvement in the method of making, repairing, and preserving roads, and defending the road funds from misapplication. Ed. 9, rev. Lond., 1827. 625.7 M11a9

——— ——————— Ed. 4, rev. and enl. Lond., 1821. 625.7 M11s4

Massachusetts. Highway commission. Standards, approved March 8, 1913. n. p. 1913. 625.7 A003

Blue prints of culverts, catch basins, drains, street railway sections and macadam construction.

New York (city) Bureau of highways. Proposals for bids or estimates, bid or estimate, bond, contract and specifications for widening and repaving with rock asphalt on a concrete foundation. N. Y., 1912. 625.8 A003nr

New York (city) Dept. of public works. Specifications for regulating and paving with macadamized pavement. 1876-81. 625.8 A003ns

CONTENTS: Fifth avenue, from 19th st. to 110th St.—Broadway in the 24th ward.—Riverside ave. between 72nd st. and 130th st.

Queens County, (N. Y.) Board of supervisors. Proposals [and specifications] for grading, regulating, and macadamizing the public highway, in the town of Jamaica, known as Locust Avenue. Jamaica, 1892. 625.8 A003q

Richmond County, N. Y. Engineer of roads. Specifications for macadam pavement. West New Brighton, 1890. 625.8 A003r

Henry P. Morrison, Engineer of county roads.

Rogers, Frank F. Macadam roads. Lansing, 1912. (Michigan. State highway dept. Bulletin no. 4.) 625.709 M58 no. 4

Smith, Jonah Walker. Dustless roads. Tar macadam; a practical treatise with numerous illustrations and tables. Lond., 1909. 625.863 Sm6

Vol. XLVIII. JANUARY, 1922. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852.

PAPERS AND DISCUSSIONS

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Vol. XLVIII. JANUARY, 1922. No. 1.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

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SOME NOTES ON THE LOCATION AND CONSTRUCTION OF LOCKS AND MOVABLE DAMS ON THE OHIO RIVER, WITH PARTICULAR REFERENCE TO OHIO RIVER DAM NO. 18.

By William M. Hall,* M. Am. Soc. C. E.

Synopsis

This paper presents briefly a history of the improvement of navigation on the Ohio River.

To maintain a navigable depth during the low stages of the river and to influence as little as possible the flood heights during the high stages, movable dams with locks were constructed.

The considerations influencing the location, design, and construction of these dams, together with some notes on operation, are discussed by the writer, with particular reference to Ohio River Dam No. 18.

Introduction

Historical.—The first work of aiding and improving navigation on the Ohio River consisted in the removal of snags, boulders, and bars, the building of dams for closing the smaller and less important channel at islands, the building of spur-dikes to narrow the channel at some of the bars and shoals, and, in later years, the dredging of shoals and the building of ice piers to protect boats from floating ice when in "harbors" or protected places alongshore. All these methods failed to maintain a minimum depth of 3 ft.

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Parkersburg, W. Va.

for navigation during dry seasons and, as a last resort, the more expensive method of improvement with locks and dams was undertaken.

The first appropriation by the National Government for the Ohio River was made in 1824, and the improvement of the river by the open-channel method was commenced in 1827. From 1825 to 1830, a private company, under a charter from the State of Kentucky, built the Louisville and Portland Lock Canal for carrying traffic around the Falls of the Ohio (Mile 604 below the head). On February 8th, 1885, the United States acquired the stock of the Company and thereafter operated and improved the Canal.

In 1870, the late W. Milnor Roberts, M. Am. Soc. C. E., made the first written recommendation of record for changing the method of navigation to that of locks and movable dams. In 1874, the late Maj. W. E. Merrill, Corps of Engineers, U. S. A., M. Am. Soc. C. E., recommended the improvement of the upper river from Pittsburgh, Pa, to Wheeling, W. Va., by a system of thirteen locks and movable dams. The River and Harbor Act of March 3d, 1875, appropriated $100 000 for starting construction on Lock and Dam No. 1 at the head of Davis Island, about five miles below Pittsburgh, which lock and dam was opened for operation on October 7th, 1885.

Since that time, by enactments at irregular intervals, locks and dams to No. 39, inclusive (Mile 529), have been constructed and Nos. 41, 43, 44, 45, and 48 have been placed under construction. Of these, thirty-three have been placed in operation.

Physical Features.—The Ohio River (Fig. 1) is formed by the confluence of the Allegheny and the Monongahela Rivers in Western Pennsylvania. It flows in a general southwesterly direction and empties into the Mississippi River, the two, near their confluence, forming the southern boundary of Illinois. The total length of the Ohio is 968 miles, and it has a drainage area of 203 900 sq. miles. The discharge of the head varies from about 1 600 sec-ft. at low water to 440 000 sec-ft. during flood, and, similarly, at the mouth, from 27 500 to 1 500 000 sec-ft. At low water the average fall is, as follows:

	Miles.	Inches per mile.
Pittsburgh to Wheeling	90	11½
Wheeling to Cincinnati	378	5½
Cincinnati to mouth*	500	4

The width of the channel increases gradually from about 850 ft. near the head to 5 900 ft. at a point 22 miles above the mouth. The extreme stages of the river as given by gauge records at various points are, as follows:

Pittsburgh, Pa.	(Mile 1),	highest stage	35.5 ft.	in 1907
Parkersburg, W. Va.	(" 186),	" "	58.9 "	" 1913
Cincinnati, Ohio	(" 469),	" "	71.1 "	" 1884
Louisville, Ky., below Falls	(" 604),	" "	70.6 "	" 1884
Cairo, Ill.	(" 968),	" "	54.8 "	" 1913

* Including 26 ft. in 2 miles of the Louisville Falls.

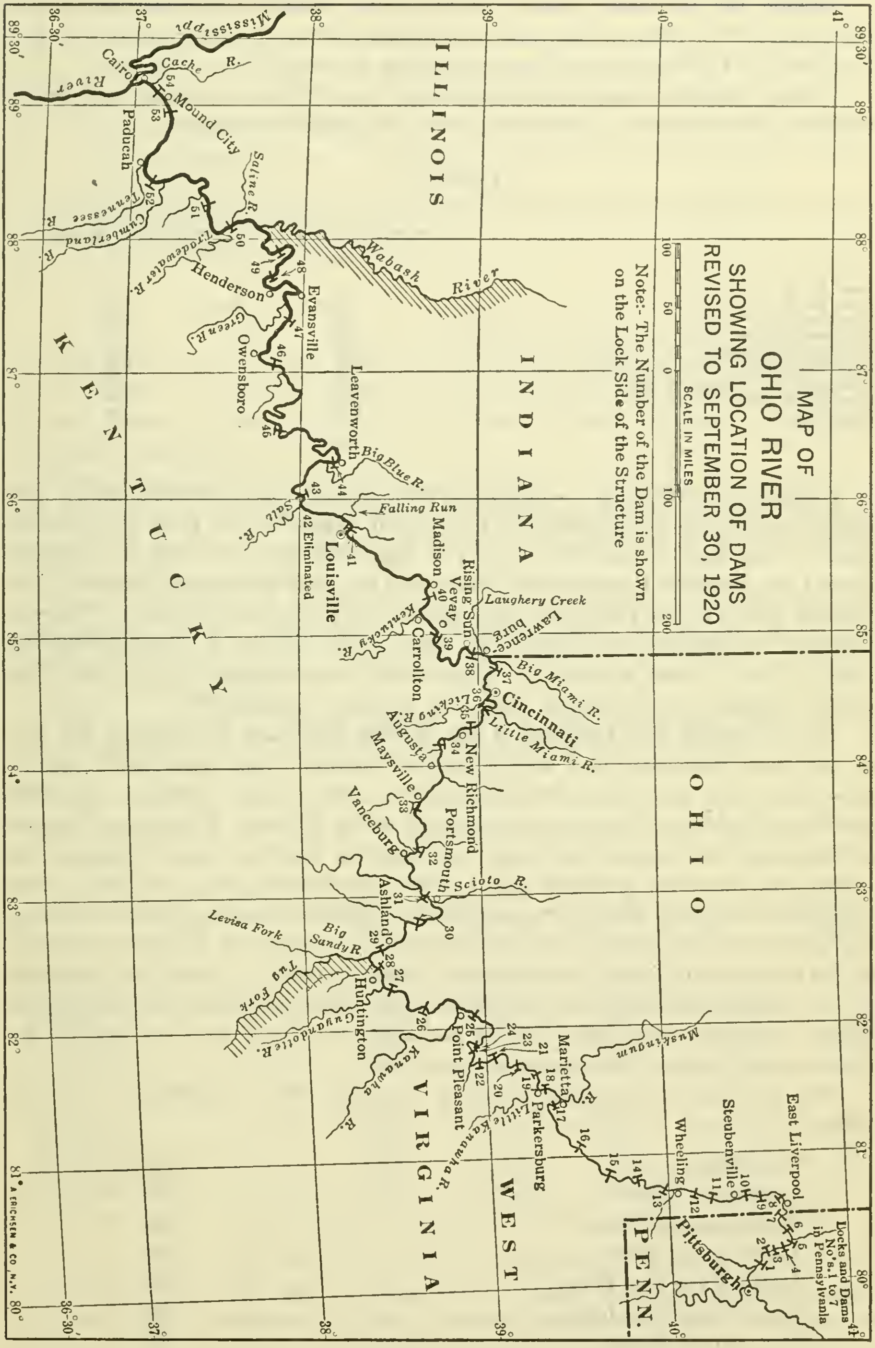
MAP OF
OHIO RIVER
SHOWING LOCATION OF DAMS
REVISED TO SEPTEMBER 30, 1920
SCALE IN MILES
100 50 0 100 200
Note:- The Number of the Dam is shown on the Lock Side of the Structure
ILLINOIS
INDIANA
OHIO
KENTUCKY
WEST VIRGINIA
PENN.
Mississippi
Cairo
River
Cache R.
Mound City
Paducah
Tennessee R.
Cumberland R.
Saline R.
Tradewater R.
Wabash River
Henderson
Evansville
Green R.
Owensboro
Leavenworth
Big Blue R.
Falling Run
Salt R.
42 Eliminated
Louisville
Madison
Vevay
Rising Sun
Laughery Creek
Lawrenceburg
Kentucky R.
Carrollton
Big Miami R.
Cincinnati
Licking R.
Little Miami R.
New Richmond
Augusta
Maysville
Vanceburg
Portsmouth
Scioto R.
Ashland
Levisa Fork
Big Sandy R.
Tug Fork
Huntington
Guyandotte R.
Kanawha R.
Point Pleasant
Little Kanawha R.
Parkersburg
Marietta
Muskingum R.
Wheeling
Steubenville
East Liverpool
Pittsburgh
Locks and Dams No's.1 to 7 in Pennsylvania
A. ERICHSEN & CO. N.Y.

FIG. 1.

During the low-water season, which occurs between July and December, the stage rarely falls to the zero of the gauges, but in many seasons it has been below 2 ft. for days and occasionally for months.

Table 1 which covers a period of several years before any dams were built, indicates the duration of navigation for 9 ft. stages or higher.

TABLE 1.

	Miles below head.	Days over 9-ft. stage.
Dam No. 1	6	79
Dam No. 6	28	117
Wheeling, W. Va	90	119
Parkersburg. W. Va	183	141
Portsmouth, Ohio	353	216
Cincinnati, Ohio	469	248
Louisville, Ky., Head of Falls	601	97
Evansville, Ind	790	198
Cairo, Ky	968	302

Extent as Water Route.—The inland water route for greatest tonnage and importance in the development of the United States is that from the easterly end of Lake Erie to the westerly end of Lake Superior. Second to it, is the route from Western Pennsylvania down the Ohio and Mississippi Rivers to the Gulf of Mexico. As Professor Hurlbert has well said in his history:* "From whatever standpoint one views the Ohio River, it has a most interesting history; but of them all none is more attractive or important than that from which it appears as a strategic avenue of National expansion."

In the settling and building of the Middle West, the Ohio River was one of the great highways, and when National, rational, and wise traffic regulations have been adopted, it will continue to exert a great influence on traffic and the upbuilding of the country through which it flows. Possibly no subject of National policy requiring large expenditure has been more abused, distorted, and used for political and private ends, during the past fifty years, than the river and harbor appropriations. Notwithstanding that condition, the project as wrought out for improving this great river appears creditable to the country and to the Governmental agents in charge. From the viewpoint of the engineer employed on the improvement now projected and in progress during the past two decades, it is no less interesting than it was to the explorer and pioneer, one to two centuries ago.

The mileage of navigable water in the Ohio River System is about as follows:

Ohio River	968	miles
Allegheny River	38	"
Monongahela River	130	"
Muskingum River	90	"
Little Kanawha River	108	"
Great Kanawha River	90	"
Big Sandy River	27	"

* "The Ohio River."

Tug Fork	12 miles
Levisa Fork	18 "
Kentucky River	176 "
Green River	190 "
Rough River	29 "
Barren River	29 "
Wabash River	100 "
Cumberland River	518 "
Tennessee River	650 "
Total	3 173 miles

The Ohio and the Great Lakes Systems will probably be connected between Pittsburgh and Lake Erie and, possibly, across Illinois, thereby making an inland system of great National importance. These projects are now being strongly advocated.

Commerce.—The commerce of the Ohio River is divided into two general classes: Package freight, loaded on the decks of steam and gasoline boats, and bulk freight, such as coal, timber, iron and petroleum products, moved by barges.

The boats that carry package freight and passengers range in size from the diminutive gasoline motor-boat to steamboats 320 ft. in length. The barge freight is carried largely on coal boats about 26 ft. wide by 130 ft. long and from 8 to 12 ft. deep.

The fluctuation in tonnage is shown in the Annual Reports of the Chief of Engineers, U. S. A., and is indicated by the extract given in Table 2.

TABLE 2.

Down Stream:	1917:		1916:		1894:
	Through lock.	Through pass.	Through lock.	Through pass.	Up and down stream.
Tons	1 316 321	1 925 623	1 397 067	2 760 797	7 795 501
Ton-miles	115 187 305	192 030 473	40 270 649	506 599 000	....
Average haul	87.5	99.7	28.83	183.50	....
Passengers	41 796	47 116	37 253	456 468	1 033 492
Passenger miles	1 329 650	2 107 412	2 373 053	8 291 800	....
Average haul	31.8	44.7	63.07	18.16	....
Up Stream:					
Tons	559 713	797 217	1 176 866	710 183	....
Ton-miles	29 625 309	41 647 722	31 654 970	19 858 843	....
Average haul	52.9	52.2	26.89	27.96	....
Passengers	20 702	69 785	39 473	625 322	....
Passenger miles	1 355 595	4 113 796	2 422 935	10 592 707	....
Average haul	65.5	58.9	61.38	16.93	....

Since 1894, the greatest decrease in tonnage has been principally in the coal from Pittsburgh down stream. The tonnage moved in 1894 was about 3 500 000 tons, of which more than 3 000 000 tons were of coal. Within the past decade the shipment of coal from the Pittsburgh District down stream has been almost entirely stopped by the adoption of a policy to conserve it

for home consumption. This policy cut off at one stroke about one-half the tonnage of the river.

The writer thinks that the building of locks and dams is not rapidly increasing the tonnage, nor will it do so until the policy in reference to its movement is more satisfactorily administered. Under present methods of operation, no company carrying passengers and freight in less than barge loads, has built up a trade and held it at a fair and profitable rate.

In 1909, the Receiver of the Pittsburgh and Cincinnati Packet Line, the largest line on the upper river, gave the following reasons for this financial condition:

1.—The non-interchange of traffic between river and rail companies;
2.—Large terminal charges by some towns;
3.—Railroad low rates at competitive points; and
4.—Suspension of boat traffic by low water.

Another reason occurs to the writer: Many boat transportation companies have built up a considerable package traffic, with almost the unfailing result of having it destroyed by a second company entering the same trade and taking a large part of the first company's business, by cutting prices to such a rate as to destroy both companies. Until these wrongs are adjusted or remedied in some way, the river will continue to carry a diminutive package commerce and fail properly to serve the public or earn a fair value on the large expenditures for its improvement.

Unfortunately, neither the Engineer Department, nor other Government agency, manages or seriously concerns itself with any part of the transportation problem other than the preparation of a sufficient waterway. This question seems to be left mainly to the boatmen, members of Congress, and the annual two-day meeting of the several "Valley Improvement Associations". It is the writer's opinion that if the package freight transportation rights of the river with its tributaries were awarded under proper and competitive methods to one reliable company, and operated under Government supervision, providing for efficient and reliable service at fair rates, the tonnage would be greatly increased. Should such a privilege for a long period be made to one of the largest and best railway companies crossing the river, thereby increasing its operating lines more than 3 000 miles, there is little doubt but that a great expansion in the tonnage would result. Such a policy, however, is in direct conflict with the popular policy of a free river and free commerce to every boat, which has been in effect since the formation of the Government; therefore, to effect the suggested change will require a struggle, like every other reform that brings great good. However, recent years of Government regulation of railway rates; of diminishing railway expansion and exploitation; of shrinkage in railway revenues and profits; and the more extensive realization by the public that the people along efficiently and reliably operated transportation lines profit many times more than the owners of the lines, will probably cause acquiescence to such a change much more readily than it would have done a few years ago. Since freight transportation by boat for short runs of less than about 500 miles, is cheaper and quicker than by railroad,

it follows as an incontrovertible conclusion that such transportation should be used and will be used when the right policy is evolved. Some Government agency should certainly be charged with the responsibility.

The capacity of the river for package and barge freight, when the improvement is completed, would easily be 25 000 000 tons annually and possibly double or treble that quantity. However, during the months the dams are up, the lockage capacity would be much below that rate.

Project for Improvement.—The appropriation by the Government for the improvement of the Ohio River for all purposes to June 30th, 1918, totals $59 500 000.

Since the design and construction of all the locks and dams on the upper half of the river, above the sill levels are nearly the same, it is evident that the large differences in cost, as shown in the Annual Report of the Chief of Engineers for 1920, are largely due to the difference in the foundations. Other causes affecting such differences are prices of work as contracted, materials purchased, and management.

From 1890 to 1908, the policy was to construct first those dams below the large cities and below mouths of large navigable tributaries. The policy was modified later and now has become fixed in favoring a continuous order from the head of the river.

It is well known that a project substituting fixed dams for movable dams would be less expensive; but the requirements of navigation and the popular fear of an increase in flood heights made the building of fixed dams in this river appear at that time to be impracticable.

The project for the improvement as now contemplated was adopted by the Act of June 25th, 1910, per the report of the Lockwood Board.* The total number of locks proposed was 54, but by the Act of August 8th, 1917, it was proposed to construct one lock and fixed dam with high lift to replace Dams Nos. 1 and 2, and by the Act of September 12th, 1913, Dam No. 42 was omitted by increasing the lifts of several others, Nos. 43 to 46, inclusive.† It is proposed to omit Dam No. 40 by the increased height made in Dam No. 41. Before the system is completed, other modifications may make further reduction in the number; the omission of Dams Nos. 51 to 54, inclusive, now appears quite probable.

In 1894, there were in operation Lock and Dam No. 1 near Pittsburgh and Dam No. 41 at Louisville, Ky. In 1912, there were 13 locks in operation and in March, 1921, 33 locks had been completed, making a total of 432 miles of improved river.

Principal Features.—The principal features of a complete lock and movable dam with equipment, as constructed on the Ohio River, are the lock, navigable pass, weir, abutment and its bank protection, upper and lower guide-walls of the lock, lock esplanade and esplanade slope, bank protection below and above esplanade, power house, operating machinery, maneuvering boat and appliances, men's quarters and grounds, and fuel for power, heat, and light. Besides these, other auxiliaries important to arrange for or provide are a turbine with

* House Doc. No. 492, 60th Cong., 1st Sess., and additional information in House Doc. No. 1159, 62d Cong., 3d Sess.

† House Doc. No. 1695, 64th Cong., 2d Sess.

complete auxiliary power machinery which replaces steam or natural gas engines when the dam is up, telegraph, telephone, mail service, highway and rail connections, farm lands, schools, churches, and amusements.

The original provisions called for a minimum navigable depth of 6 ft., a minimum width of navigation channel of 600 ft., and lock chambers 100 ft. wide by 600 ft. long between gates. The River and Harbor Act of March 2d, 1907, provided for an increase of navigable depth to 9 ft., and, for moving the existing and prospective traffic, lock chambers 110 ft. wide by 600 ft. long between gates and navigable channels from 600 to 700 ft. wide, have become standard.

With the foregoing remarks on transportation conditions and on the plans and projects for improvement, a discussion of the principles influencing the location and design, together with some notes on construction and operation, with reference to Ohio River Dam No. 18, will be given.

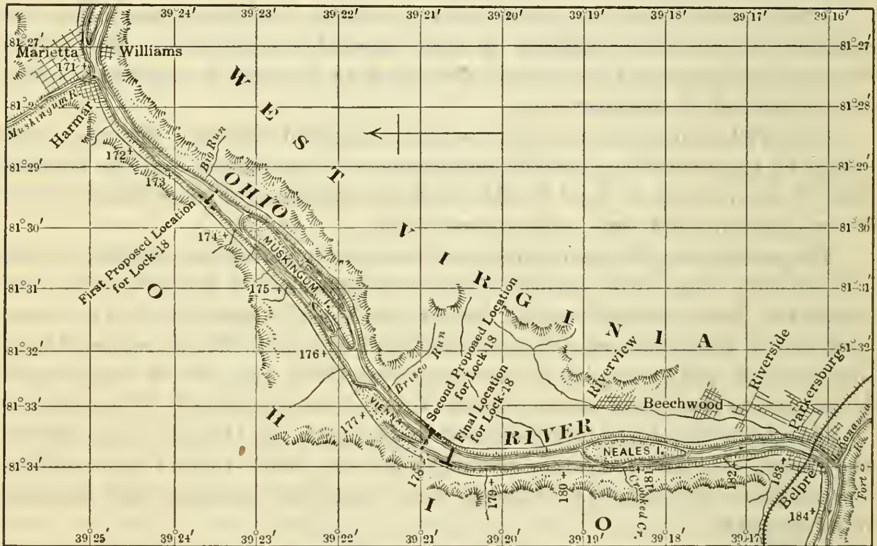

FIG. 2.

OHIO RIVER DAM No. 18.

Location.—When the construction of Dam No. 18 was assigned to the writer in August, 1901, its proposed location had been changed from Moore Junction to the foot of Vienna Island (Fig. 2). Core drill borings over the Vienna site and the site finally chosen indicated that at the latter location was the highest ledge between the mouth of the Muskingum and the mouth of the Little Kanawha, the extreme limits for the location.

The final location having been decided on, surveys were made at the site chosen, for the purpose of preparing estimates and plans. Topography on a 2-ft. contour interval was taken over the site, together with soundings, taken

20 ft. apart over the areas covered by the proposed works and 40 ft. apart elsewhere.

Core drill borings were made on the center line of the upper and lower guide-walls, the center lines of the river and land-walls of the lock, the center line of the abutment, one hole at each gate recess, and two lines of holes, one above and the other below the proposed crest of the dam. The drilling was done from an open barge 14 ft. wide and 23 ft. long by 3 ft. deep, with the floor a few inches from the keel, and equipped with a machine drill operated by a gasoline engine.

It will be observed that the lock at Dam No. 18 is located on the concave shore. The principal reasons for placing it on the concave rather than on the convex shore are as follows:

(1) The depth of water across the river admitted placing the sills at the height desired.

(2) It is on the extreme end of a bar with deep water immediately below, with no danger of having any part of the wickets and sill "sanded up"; whereas, the Island site is on a bar with the possibility of "sanding up" the wickets and pass sill.

(3) A saving in cost of from $200 000 to $400 000.

(4) As built, all the masonry has rock foundation, whereas, if the lock had been on the opposite shore, a part of it would have been on piles.

(5) The lock and approaches are less likely to "sand up", and, therefore, are less expensive in maintenance and operation.

Aside from the more favorable conditions for the foundations, in comparison with the site at the foot of Vienna Island, other reasons in favor of the site chosen are as follows:

(6) A better and easier approach from both directions.

(7) A view from a distance up stream of 4 miles, and of 2 miles down stream, whereas, on the opposite shore, the up-stream view would have been ½ mile or less.

(8) Ground above high water lies within 200 ft. of the lock, whereas, on the opposite shore, it would have been about 1 000 ft. away, a great disadvantage in time of floods.

(9) A better location for the power house and dwellings which are above high water and near the lock and power house.

(10) It is 5 miles above the business part of Parkersburg, W. Va., and the mouth of the Little Kanawha River, at the upper end of the plateau on which Parkersburg is being built, which makes its location such as to be assured that in years of future growth, that city's harbor will not be cut in two; and it is 7 miles below Marietta, Ohio, and the mouth of the Muskingum River, which is a favorable distance as to pool height and pool fluctuations for the mouth of the Muskingum and the wharf and harbor of the town. It is also so favorably located in reference to Parkersburg as to have city telephone service, city natural gas for heat, light, and power, and interurban trolley car service.

(11) The topography of the lock grounds is more adaptable to a pleasing appearance.

(12) The railroad spur to the power house is much shorter and less expensive to operate.

(13) It is near enough to the Muskingum River to give sufficient depth on the lower gate-sill of Lock No. 1 of that river, and yet far enough removed to reduce the annoyance and danger from drift, which would have existed had it been within 2 miles of the mouth of that river.

(14) Its distance from the mouths of the Little Kanawha and the Muskingum Rivers renders the annoyance from the maneuvers of the dam less than would occur to either were it closer.

Design.—A theoretical detailed computation and design* for the following parts of a set of plans of a typical Ohio River lock and dam, as reported in 1912, by Capt. L. M. Adams, Corps of Engrs., U. S. A., have been made: Rolling gates; lock walls; gate track foundations; river wall power house; steam and water power plants; valve operating mechanism; gate operating machinery; analysis of design of wicket, horse, and prop; pile, arched cellular, and solid concrete pass foundation; 91-ft. bear-trap weir and foundations.

In general, these parts are common to all locks and dams, except those which have mitered gates and those which do not have river wall power houses.

This information is a part of a public document and for that reason will not be repeated in this paper. However, the considerations and methods used in the determination of the dimensions of the various parts of the dam will be taken up in detail.

In regard to the movable parts of the dam, the writer reported to the District Officer, Maj., now Col., G. A. Zinn, Corps of Engrs., U. S. A., M. Am. Soc. C. E., in part as follows:

"In studying this design careful consideration has been given the designs of the Upper Ohio River dams, the Great Kanawha dams, and the Louisa Dam on the Big Sandy. You have already approved of the height of the sill for the pass, and of building the pass 600 ft. long of Chanoine wickets on a concrete foundation. It is therefore necessary now to discuss only the design of the weir and abutment."

In designing the weir, conditions of first importance to be fulfilled, as reported by the writer, were as follows:

1.—To regulate perfectly the height of the water in the upper pool, at all stages of the river at which it may be desirable to keep up the pass. In this case, it does not seem that it will ever be necessary to keep the pass wickets up when the river is above a 10-ft. stage.

2.—To place the weir sill so low that, when the pass wickets are down, no boat or fleet will be stopped by the "swell head" or increased velocity of water through the pass.

3.—To make the dimensions of the weir, pass, and lock such that, with the lock-gates open and the dam down, the velocity of the water will not interfere with navigation. It is also desirable to have this condition fulfilled with the dam down and the lock-gates closed.

4.—To place the weir sill sufficiently high to prevent its "sanding up". Ease of operation and regulation make it desirable to place the weir sill as high as possible.

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* House Doc. No. 1159, 62d Cong., 3d Sess.

5.—To arrange the weir for passing drift and floating ice with the least danger to the structure and the greatest ease to the operatives.

6.—It is desirable to place the sills of a bear-trap or other gate maneuvered by power, and a part of the weir sill adjacent to the pass, so low that when the pass wickets are raised at a stage below the top of the main weir sill, head cannot be produced sufficient to interfere with the raising of the pass.

7.—To have the dam of such a type that during the stages of least flow it will conserve sufficient water to maintain a full pool and also afford water for lockages.

8.—To have movable parts of the type which can be maneuvered with safety and ease.

9.—To adopt a type of dam which is the most economical in cost and in maintenance.

The Chanoine wickets and bear-traps appear, from the writer's observations on the Upper Ohio River, at Louisville, on the Great Kanawha, and from descriptions of European dams, to fulfill Conditions 5, 8, and 9 better than any of the other well known types of movable dams.

In regard to Condition 6, provision may be made against such difficulty by placing a 50-ft. bear-trap dam next to and at the same level as the pass sill. In his "Canalization de la Meuse", M. Hans says that the head referred to should not exceed 1 m. The writer believes that it is desirable to prevent its exceeding 1 or 2 ft. In the dams now being built, this condition is fulfilled by placing the sill of both traps at the same level as the pass sill.

Considering the question of tightness, Condition 7, it is believed that bear-trap dams can be made as tight as any other type of dam. Needles, curtains, gates, and, possibly, other types can be made tighter than wickets. With the use of wickets, calculations should show a shortage of water not more than once in 10 to 20 years. The lowest recorded discharge measurement of the Ohio River was taken in 1892, below the mouth of the Muskingum, the discharge being 3 255 cu. ft. per sec. Since this quantity is five or six times as much water as will be required for lockages it appears that with cover strips between wickets, sufficient water may be expected nine years out of ten, unless an artificial shortage is produced by the raising of dams up stream. Computations indicate that, with pass wickets 15 ft. high, with weir wickets, 12 ft. high, and with the pass and weir of the lengths proposed, the leakage through the interstices between the wickets will about equal the discharge of the river at a 3-ft. stage. Therefore, during several weeks of each year, needles over the interstices will be necessary.

Considering Condition 5 in reference to the passing of drift, it is found that below about a 9-ft. stage, with no wind, the drift is distributed almost uniformly over the surface of the river. As the water rises above a 9-ft. stage, with no wind, the drift goes to the Ohio or lock shore. The prevailing wind is from the west, and winds of 15 or 20 miles per hour cause nearly all the drift or floating ice to be driven against the West Virginia or abutment shore. When the bear-traps can be maneuvered readily, they afford as easy and a safer passage for drift and ice than any other well tried type of dam. As their cost and likelihood of getting out of working order increases rapidly with their

length, two 50-ft. sections were proposed for passing drift, one in the middle of the river and the other next the West Virginia shore, for that purpose when the wind is carrying drift and ice against that shore.

Conditions 1 to 4 will be considered jointly: At the site chosen there is sufficient room, without widening the river, for 500 ft. of weir, and computations were based on utilizing that width. In making the necessary computations for Condition 1, the most applicable formula is the Chanoine formula used for a similar computation in connection with the Louisa Dam on the Big Sandy,*

$$Q = m\,(L'\,H')\,\sqrt{2\,g\,(h + Z)} \qquad (1)$$

in which,

$Q =$ discharge of river, in cubic feet per second.
$m =$ constant depending on stage.
$L' =$ length of weir.
$H' =$ height of water on crest of dam above sill of weir.
$g =$ acceleration due to gravity $= 32.2$.
$h =$ height of water, or head, causing velocity of approach of water $= \dfrac{v^2}{2\,g}$
$Z =$ head due to swell caused by the water being forced through a reduced area on account of the construction of the works.

The values for m in Equation (1) and the following equations were selected from M. Hans' book, "Canalization de la Meuse," in which all calculations were based on $Z = 0.5$ ft. Mr. Thomas advises that, since the Louisa Dam is finished, he finds the value of Z about 0.35 ft. when the lock-gates are closed. Therefore, the latter value of Z was adopted, and the correct value of m for the weir for various stages of the river was found, as follows:

0.5-ft. stage, $m = 0.458$
5.0-ft. stage, $m = 0.808$
6.0-ft. stage, $m = 0.811$
7.0-ft. stage, $m = 0.830$
13.0-ft. stage, $m = 0.896$

To determine whether the weir will regulate the upper pool when the water is at a 10-ft. stage, with the top of the weir sill 3 ft. above the top of the pass sill, apply the following values in Equation (1), $m = 0.885$; $L' = 500$ ft.; $H' =$ 12 ft.; $h = 0.137$; $Z = 1.7$, the "swell head;" and $Q = 57\,700$ cu. ft. per sec.

The discharge of the river at that stage is only 54 600 cu. ft., as shown in Table 3, which gives the discharge, area of section, velocity of flow, and velocity head for the Ohio River at Dam No. 18. Therefore, it appears that with the sill of the weir 3 ft. above the pass sill, the river can be regulated to a discharge equal to a 10-ft. stage, without any spill over the crest of the dam.

The values of m and Z are only approximate. The value of Z may be considerably in error, but it is conservatively small for such conditions.

* "Movable Dams", by B. F. Thomas, M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), p. 469; or "Improvement of Rivers", by Thomas and Watt, p. 214.

TABLE 3.

Gauge.	Quantity, in second-feet.	Area, in square feet.	Velocity in feet per second.	Velocity head.
0	900	5 210	0.17	......
1	2 940	6 380	0.46	0.003
2	5 550	7 530	0.74	0.008
3	8 910	8 620	1.03	0.0165
4	13 350	9 940	1.34	0.028
5	19 110	11 030	1.73	0.046
6	26 100	12 310	2.12	0.07
7	33 390	14 420	2.34	0.085
8	40 200	15 820	2.57	0.103
9	47 100	16 920	2.78	0.120
10	54 600	18 350	2.97	0.137
11	66 400	20 540	3.18	0.157
12	73 500	21 810	3.40	0.180

In making the computations for Condition 2, Equation (2) is applied:

$$Q = m\,(L\,H)\,\sqrt{2\,g\,(Z + h)}\;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

in which.

L = length of pass;
H = height of water on crest of dam above the sill of pass; and
Z = swell head.

In these computations a "swell head" of 0.25 ft. is assumed. The problem to be solved in this case is, how high can the weir sill be placed without the "swell head" through the pass exceeding 0.25 ft. Assume that the water is at a 3-ft. stage, or 4.6 ft. above the pass sill, and that the weir is closed. It is found that there can be discharged through the pass, with a "swell head" not exceeding 0.25 ft., 9 186 cu. ft. per sec., whereas at that stage the actual discharge, as shown in Table 3, is 8 910 cu. ft. per sec. Therefore, with the weir sill not more than 4.6 ft. above the pass sill, the "swell head" should never exceed 0.25 ft.

It is found in meeting Condition 3 that if this condition is fulfilled with the water just to the top of the lock river wall (or 16.4 ft. stage) and with the lock-gates closed, it will be fulfilled under all other conditions which are likely to arise. In making this computation, the formula of Chanoine and De Lagrene, used by Maj. Lockwood and Mr. Thomas,* for a similar computation for the Louisa Dam, namely,

$$Z = m\,v^2 \left(\frac{S^2}{S_1^{\,2}} - 1\right) \frac{1}{2\,g}\;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

in which,

Z = "swell head," in this case, 0.25 ft.;
v = mean velocity;
S = discharge area of river before construction of works;
S_1 = discharge area of river after construction of works; and
g = 32.2.

Substituting the proper values in Equation (3), in which $Z = 0.25$; $m = 1.05$ instead of 1.5 when the "swell head" is reduced from 0.5 to 0.25; $v = 4.34$; $S = 24\,600$ sq. ft.; and $S_1 = 18\,250$ sq. ft.

* *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), p. 471.

Using 135 sq. ft. as the discharge area over the top of the piers and abutment, to find the height of the weir sill to give the foregoing area, apply Equation (4):

$$135 + 500\,x + (600 \times 18.0) = 18\,250 \qquad (4)$$

Solving for x, the height of the weir opening = 14.63 ft. Therefore, 18.0 ft. — 14.63 ft. = 3.37 ft., the height the top of the weir sill may be above the pass sill and not cause a "swell head" exceeding 0.25 ft. Substituting the values of Z and h from Equation (4) in Equation (5):

$$V = \sqrt{2\,g\,(Z + H)} \qquad (5)$$

the velocity of water through the pass at these critical stages is obtained. With the weir closed, and the water 3 ft. deep on the pass sill, the velocity is 2 miles per hour; and when the water is at the top of the river wall of the lock, with a weir sill 3 ft. above the pass sill, the velocity is 4 miles per hour. It is not believed that a velocity of less than 5 miles per hour will seriously interfere with fleets of empty barges going up stream. During construction, in 1908, such fleets passed between the lock and weir coffer-dam against a 7-mile current.

Relative to Condition 4, from experience at other dams, it is known that when the sill is placed too low, there is likely to be serious trouble from sanding.

After considering all these conditions and the development of the bear-trap at that time, the writer recommended that the weir be divided into three parts as follows:

First.—Next the pass, a bear-trap dam, 50 ft. long.

Second.—Chanoine wicket, 400 ft. long, operated by a bridge.

Third.—Next the abutment, a bear-trap dam, 50 ft. long.

Also, that the sill of the bear-trap next to the pass be placed at the same level as the pass sill, and that the remainder of the weir sill be placed 3 ft. above the top of the pass sill, or 1.4 ft. above low water. These recommendations were adopted, except for the wicket weir which was made 300 ft. long and the pass, which was made 700 ft. long, as ordered by the Chief of Engineers. This resulted in easier and possibly safer navigation for some fleets of boats, but more difficult operation, and, in case of a rapid rise, an increase in the hazard.

In the report of the Lockwood Board* is a diagram of a large coal tow for the upper river. This tow is 130 ft. wide by 696 ft. long. There is also a diagram of one of the largest fleets on the river below Louisville, 312 ft. wide by 1 132 ft. long. It is thus evident that in order to operate with ease and efficiency a series of movable dams, the navigation passes must increase in length as the river increases in width. As the weir of Dam No. 18 was designed before any of the others between it and Dam No. 6, its length could not be governed by the lengths of any weirs on the river, except those of Dams Nos. 1 to 6. If designed in order, it is evident that each weir in succession down stream,

* House Doc. No. 492, 60th Cong., 1st Sess., p. 18.

should have the capacity of the one above when fully open, plus the tributaries emptying into its pool.

Wickets.—The location of the exact place for hinging the wickets was studied from both the theoretical and historical points of view, the design of the wickets for all other dams of which plans could be obtained, being considered.

The correct general principle for the hinging of the pass wicket may be briefly stated as follows: The axis of rotation for pass wickets should be placed as low as possible, but at such height that they will never automatically go on swing from head of water alone. Computations for Dam No. 18 indicate that the pass wickets will never go on swing without some force other than the water.

When operated by a bridge, the general principle for hinging the weir wickets may be briefly stated thus: The axis of rotation should be placed so that the wickets will automatically go on swing just at the time the lower pool rises to that height at which the dam should be lowered. In general, the wickets will not be depended on to work automatically, but are designed to work in this manner in case of emergency, and for ease in operation. Should a rapid rise occur, and the attendants be slow, or should an unexpected rise occur at night and not be observed, the upper pool may be relieved by the automatic swinging of the weir wickets. Computations for the weir wickets of Dam No. 18 indicate that they will automatically swing at the time the upper pool level rises 6 in. over their tops and the lower pool level reaches a stage of about 9½ ft. above low water.

It would probably be better to hinge the weir wickets so that they would not swing with less than 1 ft. on the crest. However, there is not entire agreement on that rule. After years of operation, the writer believes the hinge point for the pass wickets is satisfactory. For the weir operated with a bridge, the percentage for butt might be slightly increased. For weirs operated with a boat, it is never desirable to have wickets hinged so as to swing automatically. If hinged to swing so easily, they might possibly fail to hold the maneuver boat at stages over the crest. On one occasion a rise with about 18 in. of water on the crest, head reduced to about 4 ft., and acres of heavy drift against the maneuver boat and dam, caused the pass wickets below the boat to swing, dropping the boat over them into the lower pool.

For this study, the writer had computations made which indicated that with very slow current, 6 in. on crest, and with the following height of heads to hinge the weir wickets so they would just swing, the percentage for breach should be as given in Table 4.

TABLE 4.

Head, in feet.	Length of breach, in feet.	Length of wickets, in feet.	Percentage of breach length.
8	5.28	12.92	41.
9	5.48	12.92	42.4
10	5.71	12.92	44.2
11	5.95	12.92	46.

The designer must consider two forces, namely, the increased pressure against the butts by increased current, and the increased pressure at the top of the chase by increased pressure of the drift or of the maneuver boat. With these conditions known, and his method of operation determined, he is then prepared to determine his hinge point.

After the plans were prepared, the length of the pass and weir wickets and the relative length of the butt and chase were reported for each, as follows:

Pass wickets:

16 ft. $0\frac{1}{4}$ in. long.... { Breach, 8 ft. $2\frac{1}{4}$ in., 51.12% of length.
Chase, 7 ft. 10 in.

Weir wickets:

12 ft. $11\frac{1}{16}$ in. long.. { Breach, 5 ft. $7\frac{9}{16}$ in., 43.5% of length.
Chase, 7 ft. $3\frac{1}{2}$ in.

The wickets were of long-leaf yellow pine which the writer considers the best wood for the purpose, because it remains true to its original form. In many of the dams, white oak wickets have been used exclusively. The difference in their strength or life for use as a wicket are not material considerations.

The Bebout Wicket.—The only improvement of the Chanoine wicket, which has been used is the Bebout wicket. The first wicket of this type for practical use was installed in the pass of Dam No. 18 in 1914.

Fig. 3 is a view of Bebout and Chanoine wickets at their junction in Dam No. 22, and Bebout wicket horses assembled on their foundation.

The advantages claimed for this wicket over the Chanoine are:

1.—It can be raised with ease and without loss of time at any open-river stage up to the top of the wicket.

2.—It can be raised against any differences in pool levels, if sufficient power is applied at the chains; it is possible to raise it against an 8-ft. difference in pool levels with comparative ease and without delay.

3.—It can be lowered under all conditions of river stages and pool levels.

4.—With adaptable appliances, the wicket may be maneuvered from either the upper or the lower pool.

5.—During maneuvers all parts have little exposure to drift, both floating and submerged, whereas Chanoine wickets have great exposure.

6.—When raising wickets, drift cannot, except in extreme cases, obstruct or become entangled in the parts to such extent as to prevent this maneuver.

7.—The sill and foundation of the dam, and the wickets themselves may be completely covered with sand and gravel without serious delay to the maneuvering.

8.—A boat, barge, or heavy drift in striking the top of the wicket will cause it to collapse without damage to boat or dam.

9.—In case of a sudden rise overtopping the wicket, it will either trip or else form no obstruction to navigation.

10.—It is impossible to have the dam caught by a sudden rise in the river, and not be able to lower the wicket.

11.—The sill and foundation of the dam can be washed by raising the butts of the wickets in the same manner as with Chanoine wickets.

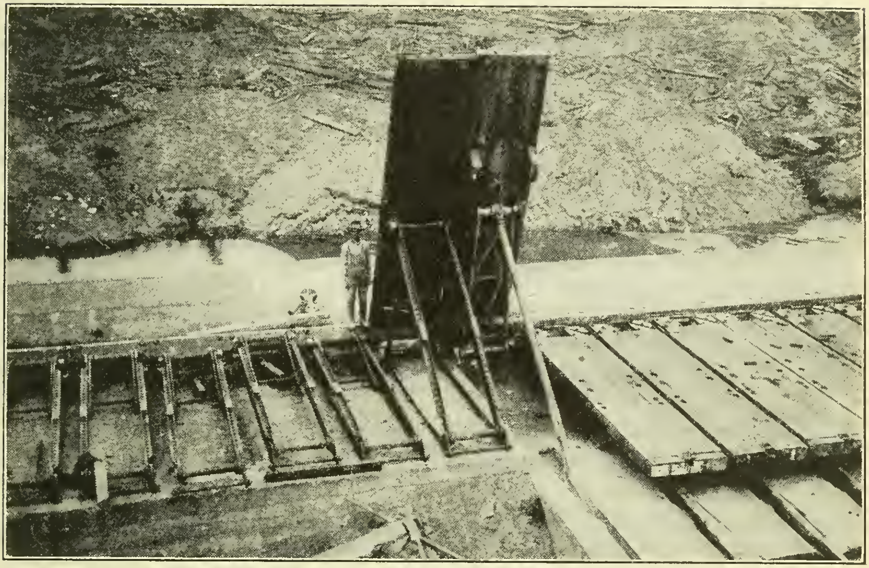


FIG. 3.—BEBOUT AND CHANOINE WICKETS AT THEIR JUNCTION IN OHIO RIVER DAM NO. 22, AND BEBOUT WICKET HORSES ASSEMBLED AT THEIR FOUNDATIONS.

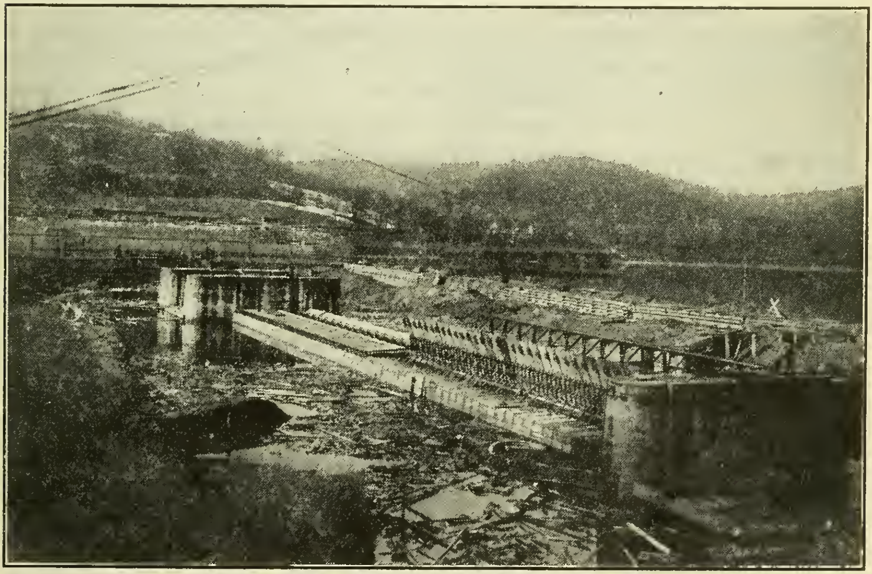


FIG. 4.—VIEW OF COMPLETED WEIR, DAM NO. 18.

12.—The maneuvers are direct and are made in one operation. Raising and lowering may be accomplished in a short time.

13.—The first cost of wickets and foundation should be no greater than that of Chanoine wickets.

14.—For the same factor of safety, the foundation will be materially cheaper; or, for the same foundation, the factor of safety will be greater.

15.—The maneuvers may be performed from the lower pool in case of emergency.

16.—Less equipment and no powerful sinking device is required to sink the wickets.

17.—The ease with which wickets may be maneuvered should reduce the operating costs. There is less wear and tear on the operation of the appliances, wickets, and foundation.

18.—Nine or ten men should be able to operate a lock and dam instead of thirteen or eighteen, as may be required to operate dams with Chanoine wickets.

19.—Since the dam may be raised at any stage of the river, it is unnecessary to allow the lower pool to drop below normal and a 9-ft. stage will be provided without interruption.

20.—Complaints from boating interests will be reduced to a minimum, since no boat should be stranded when dams are raised.

21.—A saving will be effected by the removal of a large number of long-distance telephone calls. It will not be necessary to telephone except to give notice of the approach of quick rises. Each lock-master can to a great extent operate his dam independently of other dams.

22.—The wicket is well adapted for use as an emergency gate and could be used as such during the renewal or failure of a lock-gate, and could be made to serve the purpose of a coffer-dam during repairs to locks.

23.—It is possible to dispense with one bear-trap and all the present weirs at the upper river dams, replacing them with a navigable pass-section equipped with the new wickets.

24.—Both the bear-traps and the Chanoine weir could be dispensed with at the lower river dams.

Since the Bebout wickets are maneuvered successfully against heads of 10 ft., or more, a cluster of two or three for passing drift near each end of the pass is such a great convenience, that two or more clusters may eventually be considered essential in the passes of all the dams.

Bear-Traps.—In 1904, when the writer was preparing the plans for the bear-traps for Dam No. 18, the principal traps then known to him were the wooden ones in Dams Nos. 1 and 6, designed in 1898 and 1900, the two steel traps in Herrs' Island Dam, Allegheny River, the three-leaf dam in the Louisville Chute, and the wooden three-leaf dam in the Mississippi River at St. Paul, Minn. All these dams were in service except Dam No. 6, and the engineers directly in charge were believed to consider each suitable for its purpose.

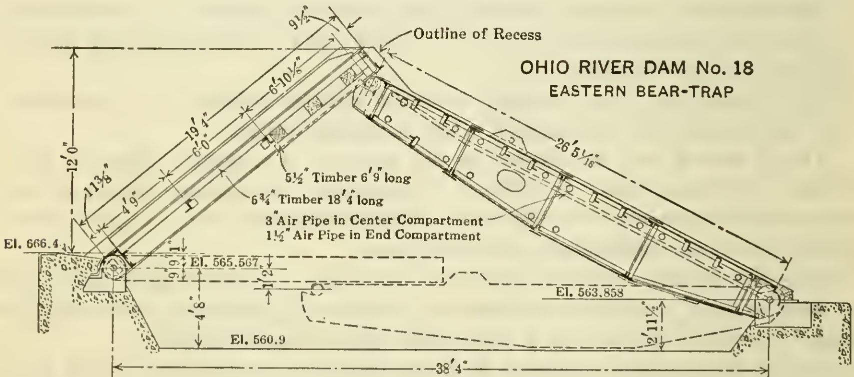
After discussing the merits of each with the District Officer, and after a study of the best papers he could find on the subject, the writer recommended

steel traps for Dam No. 18, and with the aid of the Junior Engineer, the late C. J. Rannells, Assoc. M. Am. Soc. C. E., prepared the designs and working plans for two 50-ft. traps. Fig. 5 is a cross-section of the eastern or smaller bear-trap.

The traps were completed in 1908 and put in operation in May, 1910, and have always maneuvered with ease, under any conditions of river.

The years of experience with these traps, and the many other traps since constructed for other dams, has demonstrated that for regulating the stage of water in the pools, for ease of operation, and for safety of parts, the bear-traps, in 50-ft. lengths and as since built in 91-ft. lengths, are the ideal movable parts. The sills may be placed at the same level as the pass sill without fear of "sanding up" seriously interfering with operation.

It is believed that the maneuvers of the entire dam will be more efficient and made much easier by placing both traps next to the abutment and the wicket weir next to the pass wickets. With this arrangement, the weir wickets



SECTION OF EASTERN BEAR-TRAP

FIG. 5.

and the pass wickets can be operated by the same maneuver boat, thereby eliminating the bridge which is much more difficult to maneuver and to keep clean of drift than the wickets alone. Therefore the writer would recommend placing both bear-traps next to the abutment, the 400-ft. wicket weir, with 11-ft. wickets, between the traps and the pass, and make the bank protection below the abutment sufficient to withstand the increased scour.

Care was used in the design to obtain the greatest possible head for acting on the leaves. The girts were made stiff enough to lift the dam with air under only one-third, or one compartment, of the lower leaf, or stiff enough to admit of a deflection of not more than 1 in. when lifted with water alone, the water entering from one pier only and giving a maximum pressure at one end and zero at the other. It was believed that the great deflection under such conditions was the most serious defect. The galvanizing of the thin parts of metal and the use of nickel steel were considered; but plain carbon steel was used throughout on account of the cost and the difficulty in galvanizing such large sheets as those used on the skin. For convenience in cleaning,

repainting, or in making repairs, manholes were placed in the lower leaf and in the girts. Wooden water seals were used for closing the gap between the leaves and the masonry. When the central trap was cleaned in 1914, the seals were found to be entirely destroyed, and new ones were not considered essential, since no difficulty had been experienced in operation. In the later designs, metal seals are being installed.

The dimensions of the leaves were as follows:

Westerly, or larger bear-trap:
 Length of lower leaf, 34 ft. $0\frac{13}{16}$ in.
 Length of upper leaf, 24 ft. $4\frac{13}{16}$ in.

Easterly, or smaller bear-trap:
 Length of lower leaf, 26 ft. $10\frac{1}{16}$ in.
 Length of upper leaf, 19 ft. 4 in.

All the dimensions are given from center of hinge to extreme end.

Ordinarily, the most severe stresses will occur under the following three conditions of operation:

1.—In the girders of the lower leaf, with low water in the lower pool, and a full pool above the trap partly up, and a head of water applied with sufficient force to raise the trap to the top.

2.—In the girders of the upper leaf, with low water in the lower pool, and a full pool above, and the water emptied from the recess under the trap.

3.—In the girts of both leaves, should the trap be lifted by water pressure alone, applied with sufficient pressure at one end of the trap to move it and diminishing to zero at the other end.

Computations were made to insure strength enough to withstand the stresses which might be produced under other assumptions not so severe. Since the lower leaf is likely to be subjected to more severe conditions than the upper leaf, the same working stresses were not used. The working stress used in the girders of the lower leaf was 6 200 lb. per sq. in., and in girts 8 000 lb. per sq. in. The estimated cost of the movable part of the eastern trap, 12 ft. high, was $148.38 per lin. ft., and that of the western trap, 15 ft. high, $212.28 per lin. ft. From 1 to 1½ min. are required to raise the bear-traps at any stage with 18 in. of head or more, and they may be lowered at any stage within 1 min. They maneuver with either water or air, or both. Ordinarily, only the water pressure is used.

The widths of the piers from which they were operated and supplied with water are 11 and 12½ ft., respectively. The hydraulic head has always been sufficient to operate the traps when the wickets are up. In submitting the plan for the traps to the District Office, the writer stated, "it appears that, if the mechanical working of the traps now in service was perfect, it would be better to make the traps longer than 50 ft. When the working of the traps has been made perfect, the economical length of any series of traps will depend largely on the character of the foundation, but such lengths will generally fall between 75 and 150 ft." The standard length for the Ohio River bear-traps is now 91 ft. in most of the dams, and they are placed be-

tween the pass and wicket weir. They are now built and operated with the same confidence of success as lock-gates or other similar structures.

Plan for Lock.—In 1902, when the plans and specifications for Lock No. 18 were submitted to the District Officer, Locks Nos. 1 and 6 had been completed and Nos. 2 to 5, inclusive, were under construction. The plans for Lock No. 18 included the following details which differed from the dams previously mentioned.

1.—Masonry all monolithic Portland cement concrete, instead of cut stone as used in Locks Nos. 1 and 6; or of natural cement faced with Portland cement or with timber on the chamber walls and coped with stone like Locks Nos. 2 and 5 then being built.

2.—Faces of chamber walls and guide-walls battered $\frac{3}{4}$ in. in 12 in. instead of being vertical.

3.—The top width of river wall along the chamber, 8 ft. instead of 11 ft.

4.—The flushing of conduits and drift chutes omitted and, instead, each gate recess provided with stop planks and sump for use in annual unwatering and cleaning.

5.—Gate and valve machinery operated by fluid or air machinery instead of steam.

6.—Ten emptying and filling valves instead of sixteen, but with equal capacity.

7.—Each valve operated by its separate engine instead of all being operated by one engine.

8.—Valves rectangular instead of circular.

9.—The pipe well and conduit omitted and, instead, the pipes laid across the lock, descending and ascending the lock walls in open channels in the concrete.

All these features were approved except the battering of the chamber walls and the form of the valves, and, except for the number of valves, have become standard construction on Ohio River dams. Rectangular valves have since been introduced. All engineers in charge of the operation of locks with battered walls, who have expressed their opinions to the writer, prefer the battered rather than the vertical walls. The battered face is not cut so rapidly by the rubbing of boats; it also enables boatmen to walk the gunwales of barges when moored in the lock and, for an equal area of section, it gives a slightly increased factor of stability. The fact, however, that the lock walls when completed were of the vertical type was good reason for not making the change. All the lock masonry is designed for stability as gravity walls; the river wall on the assumption of being completely unwatered and with a stage of the river to the top of the wall; the gate tracks and Poirée dam foundations on a similar hypothesis, and the land wall and guide-walls on the hypothesis of being surcharged retaining walls. They were not designed on the hypothesis of having a full head of water under the entire foundation masonry beds, but it was considered that such a head might occur over small areas of the foundation. Thinner walls of reinforced concrete were considered for the guide-walls, but were discarded on account of the danger from shock by heavy boats or by fleets of loaded barges.

Construction Features of Dam No. 18.

Plant and Materials.—In building Lock No. 18, the sand and gravel required for the concrete was taken from the river bed near the site. Coal was obtained by barge from river mines, and nearly all the remaining materials were received on a spur track of a railroad the line of which passed along the top of the bank within 50 ft. of the work. Materials were transferred to the work from storage sheds and yards along the siding by tramway cars operated by men and mules.

The contract for building the dam and abutment was let about a year before the lock was completed. The contractor received materials in the manner previously described, except that his coal and some other materials arriving by rail were received near the West Virginia river bank on a siding about 800 ft. from the abutment, and carted to the work by teams. Materials from the latter siding were transferred to the work by a cableway. The cable was maintained as required by law at a minimum height of 90 ft. above low-water datum. The towers were set well back from the bank, making a clear span of about 1 760 ft., thus securing protection against accident and giving adequate storage and loading space for materials and plant.

The best and most economical method of transfer to be adopted for building any particular lock and dam will be influenced by some of the following conditions:

1.—The economy of extending standard railroad track to the river bank alongside the work, or down into the lock coffer-dam.

2.—The use of a cableway is more expeditious than other methods.

It is conceded that every flood over a coffer-dam, when work is fully under way, will cost in actual damage and expense rarely less than $1 000 and usually much more. The cableway is especially advantageous and adaptable to this work, since the cost and time of transfer of the materials and plant from the coffer-dam in case of flood is greater by other methods. Whether or not its use is advisable, depends on the quantity of material which can be moved advantageously. In the writer's opinion, the sand and gravel required for the concrete can be unloaded more economically from the barges, on fixed or floating derricks, and it is more economical to move the concrete from the mixers to the forms by tramway, or by chutes, than to move it and place it by cableway. This economy is due to the fact that buckets from the cableway are not easily swung to the forms. Also, the sand and gravel must be unloaded from barges moored under the cableway in the navigation channel, which is a dangerous process at stages below 6 ft., and impracticable at stages a little higher; thereby resulting in serious delays to concrete construction. The work advantageously done by a cableway and for which it is especially adapted is the transfer of all materials to their place in the coffer-dam enclosure, and the transfer of plant and tools to and from their place of usage.

Coffer-Dams.—The construction of the No. 18 lock, dam, and abutment required four coffer-dams: One for the lock, one for the abutment in which one section of bear-trap foundation was included, one for 650 ft. of the pass, and one for the weir, bear-traps, and the remaining 50 ft. of pass. For building the

guide-walls of the lock, levees 8 ft. in height were thrown up from material excavated in preparing the foundation.

The proper order for building the coffers is, first, the lock and abutment coffers; second, the pass coffer; and, third, the weir coffer. It is not important whether the lock coffer or the abutment coffer is started first, or whether both are started together. The other two, of course, must follow in succession; but it is important to have the masonry and the bank back of the masonry finished and sufficiently protected against scour, since the latter coffers produce a "swell head" and increased current.

Due to the high sill of the weir, it is essential to build the pass before the weir. On account of the "swell head" and high velocity of current, it is expensive, more or less dangerous, and detrimental to navigation to hold the weir and pass coffers in the river over winter.

The program followed by Government forces and by some contractors on lock and dam construction is to complete the work and remove the coffers in early winter. Some of the slower contractors increase the number of coffers to five, the fifth being made to enclose the bear-traps and adjacent end of the pass. It is unusual for the construction of the lock to be completed in one season; hence, it is customary for the lock coffer to be continued in service over one winter.

For the lock, a crib coffer was built, enclosing the entire lock and lock area as planned and specified by contract. The abutment and dam box coffers were specified with the option of changing, subject to approval by the contracting officer.

In studying the economical height of these coffers, the writer used the hydrograph sheets of daily stages at Marietta, and from them computed the probabilities of coffers varying in height from 10 to 20 ft. being flooded during the working season. With the adopted height of 18 ft., it was concluded that the work would probably be flooded once during the working season from May to December.

The timber and metal for the lock coffer was salvaged from the coffers which preceded it. In constructing the lock coffer, a channel was dredged with a dipper-dredge, the bed-rock being scraped as clean as possible. The cribs were built in water and sunk on the rock ledge thus prepared. The logs forming the longitudinal walls were barked on the inside, and those forming ties were wrapped with several rings of oakum to retard seepage. To reduce leakage to a minimum all the wall cracks were carefully covered, and selected material was used for filling the pockets. This coffer-dam was built in the spring of 1903 and was in use until the fall of 1904, going through a winter and spring of much high water and a long run of ice from 12 to 18 in. thick. The resulting damage was repaired at a cost of less than $50. Two 12-in. centrifugal pumps easily kept out the leakage, and at stages up to within 2 ft. of the top of the coffer-dam, one pump removed all the leakage. The inside wall was vertical, and stood about 10 ft. from the concrete masonry. The top being so near the permanent work, proved a great convenience for storing materials and offered no obstruction to the transfer of materials from barges and other boats by derrick-boat into the concrete forms or to the top of the

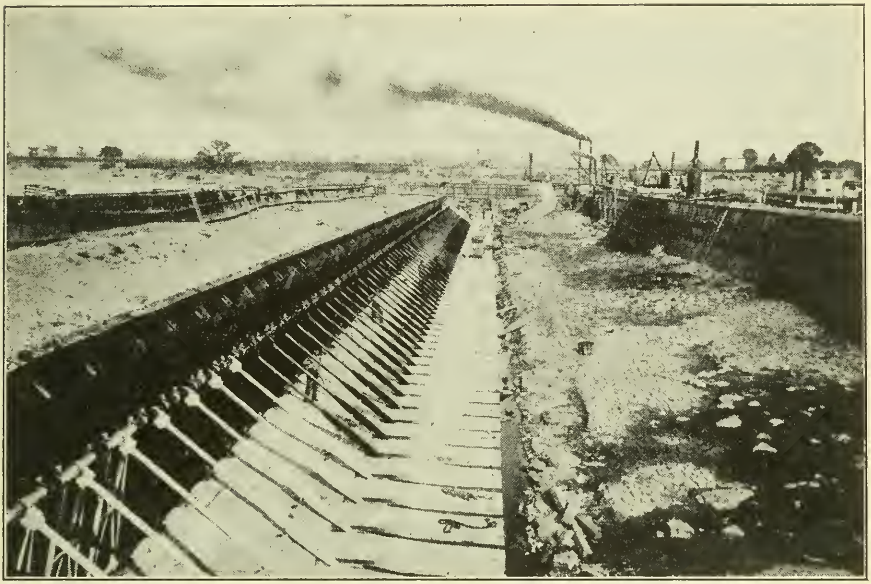


FIG. 6.—VIEW OF PASS MASONRY, DAM NO. 18, OHIO RIVER.

FIG. 7.—DAM NO. 18, OHIO RIVER: VIEW OF COFFER-DAMS AFTER 8-DAY FLOOD, NOVEMBER 30TH—DECEMBER 10TH, 1905.

wall. This proved to be more economical than the box coffer, with its top 40 ft. or more from the masonry, which is a serious obstruction in the transfer of materials required in the work.

The coffer which enclosed about 600 ft. of the pass, was built in 1905 and was of the box type. It was 602 ft. long inside by 150 ft. wide at the river wall and 200 ft. wide at the outer end, and rested on bed-rock with the top 18 ft. above low water. The upper arm was 20 ft. high at the river wall and 32 ft. high at the outer or channel end. The contractor chose this type at his own option; whereas the writer believes that a crib coffer-dam of the type used for the lock would have been more economical for that part of the pass where the high elevation of bed-rock made necessary a wall only 20 to 25 ft. in height. The pass coffer was poorly built and was wrecked when overtopped by a flood, as shown on Fig. 7. Presumably built to hold out water at 14 to 16-ft. stages, it was effective only to 12 ft., on account of leakage, at which stage three 12-in. pumps were required continuously.

Five separate attempts were made at levee and coffer building for the abutment. Work was first commenced in June, 1905, and continued through the seasons of 1905, 1906, and 1907. The abutment masonry, sheet-pile protection, and the bulkheads extending the seal into the bank behind the abutment, were not finished until November, 1907. The masonry plan showed the foundation bed 22 ft. below low-water level, and the contractor made two unsuccessful attempts to build the abutment within a simple levee made from the light bank material. The third attempt was a rather light box coffer-dam. The two levees and the light box were entirely swept away by the river before the concrete forms were built, and later a second box coffer was lost. The fifth and successful attempt followed the construction of a fairly substantial box coffer, protected with round piles and rip-rap.

The weir coffer for Dam No. 18, built by hired labor, was placed by having both lower and upper arms run out from shore simultaneously and connected by the channel arm. The bed-rock was from 14 to 23 ft. below low-water datum. The bed on which the sheeting stood was prepared with dredges excavating or refilling as required to level it to 14 ft. below low water. The lumber for the coffer-dam was framed on shore and on a work barge, and erected in position alongside. The width of channel left for navigation between the coffer-dam and the river wall over the pass sill and wickets was 384 ft. and, in addition thereto, the lock chamber was open.

A report made in reference to the coffer-dam while the work was in progress is, in part, as follows:

Size inside, 590 by 225 ft.
Height of upper arm, 37.5 ft. at shore to 32.0 ft. at outer end.
Length of upper arm, 590 ft.
Pumps required at 12-ft. stage of water, four 12-in. centrifugal.
Extreme lift by suction, 17.0 ft.
Extreme lift by discharge, 21.0 ft.

The difference in the efficiency of the three coffers in holding out the water was so great that it is worthy of note:

1.—The crib lock coffer set on bed-rock was effective and the work of construction was continued through a flood slightly above a 16-ft. stage.

2.—The weir coffer, with a sump 23 ft. below low water, was effective up to a stage of 12 to 14 ft.

3.—The pass coffer, with a sump about 14 ft. below low water, was only effective from 8 to 10-ft. stages, and actually collapsed at a 9.5-ft. stage, wrecking all the plant inside. Such differences in the efficiency of the coffers had great effect on progress and on the cost of the permanent work.

Two things of great importance in building a coffer-dam are, first, to obtain the service of a designing engineer of experience to select the type best adapted for the particular purpose and duty; and, second, to engage on its construction a foreman or mechanic who can be relied on to close cracks, wrap tie timbers or rods, and select and place filling material so as to reduce the percolation to a minimum. Few construction details pay greater returns for vigilance than in the building of a deep coffer-dam.

Swell Head.—Observations taken October 23d and 24th, 1905, to determine the "swell head" produced by the coffers are as follows:

October 23d, 1905:

10 A. M.—Water at lower end, upper guide-wall...Elevation 580.89 ft.
Water at lower end, lower guide-wall...Elevation 579.01 "

Head .... 1.88 ft.

Stage about level with top of 16-ft. coffer-dam and falling.

5 P. M.—Water at upper guide-wall............Elevation 580.18 ft.
Water at lower guide-wall............Elevation 578.55 "

Head .... 1.63 ft.

October 24th, 1905:

9 A. M.—Water at upper guide-wall............Elevation 578.11 ft.
Water at lower guide-wall............Elevation 576.89 "

Head .... 1.22 ft.

The normal regimen of the river at a 16.0-ft. stage before work was commenced was 24 000 sq. ft. The approximate area of the openings, on October 23d, 1905, was 11 080 sq. ft.

During the winter and spring following these observations, the navigation channels between the coffer-dams were scoured to bed-rock, from 17 to 20 ft. below low-water datum, but the paving and rip-rap was not injured.

This restriction in such a short and shallow channel over the pass produces the swiftest current caused in the construction of these locks and dams, and is near the maximum which Ohio River boats find tolerable. Under such conditions, ascending packets and gasoline boats sometimes used lines to pass the dam and occasionally turned back; towboats cut their tows in two or more parts during the two winters this condition existed. Under all conditions and

positions of the coffer-dams, the maximum "swell head" and swiftest current usually occur at a stage which is about the top of the obstruction and is generally greater on a rising than on a falling river.

Masonry.—Fig. 4 is a view of the completed weir. Fig. 6 is a view of the pass masonry. The 200 lin. ft. in the foreground varies in thickness from 12 to 36 in., the thinnest wicket foundation masonry on the river. The wickets that it carries, have been in successful operation since 1910, which demonstrates the great economy of a rock foundation near the sill level and, also, that a very thin concrete slab well anchored to the ledge is sufficient.

For the pass, it was computed that under extreme conditions there might possibly be an upward pressure of 53 000 lb. against a single wicket foundation slab, 4 ft. in width. The concrete foundation for the pass is 27 ft. wide by 700 ft. long and varies from about 12 in. in thickness at thinnest part of the slab to 15 ft.

Two plans were considered for anchorage, one of which required four 2½-in. bolts for each 4 ft. of the slab, two in the upper edge and two in the lower, with the intervening concrete reinforced with steel rods. The other plan required two 2½-in. and six 1-in. hurter bolts into bed-rock for each 4 ft. of slab, or, in other words, for each wicket. The latter plan was finally approved, except that only two of the 1-in. hurter bolts were authorized to be made for anchors into the bed-rock. Therefore, as built, where the concrete is less than about 6 ft. thick, it is anchored to the bed-rock with four bolts for each wicket, two of which are 2½ in. in diameter and two 1 in. in diameter. The 2½-in. bolts were placed about 4 ft. into bed-rock and the 1-in. bolts about 3 ft. therein. The anchor-bolts for the bear-traps are 2¼ in. in diameter and are placed 4 ft. into bed-rock. When the grout around one of the 2½-in. bolts which went into the bed-rock only 42 in., had stood for less than a day, it failed to move by a lift of over 20 tons, the greatest pull for which facilities were available.

In laying the foundation, great care was used to make an impervious joint to the bed-rock foundation for the upper third of its entire surface. In other words, the seal between the upper and lower pools was made along and immediately below the upper face of the dam. To make this seal as perfect as possible, all loose shale was removed, and the bed-rock was scrubbed with brooms and water. Thus prepared, fresh mortar was spread over the foundation bed, followed by concrete. In placing the foundation layer, care was used to see positively that no stream of water crossed it, and that any stream which came up through a crevice in the bed-rock was conducted out below the dam without producing any head or upward pressure. Under the lower two-thirds of the foundation, drains were inserted at intervals of about 20 ft. to carry off any water which might seep in. All concrete up to the top of the rock was placed without forms, thus securing bond into all the interstices of the ledge.

The foundation for the chamber walls of Lock No. 18 was prepared by excavating to a depth of 1 ft. below the chamber-floor level, carefully removing all loose rock and cleaning with hose and brooms. Immediately on top of the ledge thus prepared and drained, grout was spread, in order to make as

nearly as possible an impervious joint between the concrete wall and the bed-rock. For some locks on the river, a key about 2 ft. by 2 ft. was cut into the rock along the center line of the lock walls.

The superior quality of the structures with the masonry laid on rock ledge over those laid on piles appears to the writer a more important reason for seeking a location with rock foundation and for holding to it when found, than even great differences in cost.

Most of the old cut-stone locks and dams built from 25 to 75 years ago show serious signs of failure. It is entirely possible that most of the locks and dams being built in the Ohio River will be satisfactory for the purpose intended, without change in design, for 100 years or more. Therefore, it appears desirable to take every reasonable precaution to obtain excellency of work.

For that part of the pass foundation of Dam No. 18, which is more than 8 ft. deep, and for all the wicket weir foundation, a plan was prepared for the cellular type, but the bid for the solid type proved to be the more economical. For the bear-traps only the cellular type was planned. In placing the cellular masonry for the bear-traps, drains were used to relieve any head which might otherwise occur. However, entire dependence was not placed on such expedients, but the cellular bear-trap masonry was bolted to the ledge with 2¼-in. bolts. There were some indications of the passage of water through the bed-rock, principally in the sandstone where anchor holes were drilled, water spurting 3 or 4 ft. from several of the anchor holes for the westerly bear-trap. It was the usual custom to place all the masonry in monoliths about 30 to 35 ft. long, the full width of the wall. In placing the monoliths, the rule was to key alternating sections with from one to three vertical keys about 2 ft. wide and from 6 to 20 in. deep, at intervals of not more than 8 ft., and not more than 6 ft. from the outside surface of the wall. Where the nature of the design would permit, concrete was placed continuously from the foundation bed to the finished top, to prevent a horizontal plane of weakness, otherwise, horizontal keys were placed about 2 to 2½ ft. wide and about 1½ ft. deep. In the wicket pass and weir, care was taken not to permit stoppage closer than 8 ft. from the sill level, thereby insuring a monolith with sufficient weight to hold the wickets. The concrete sections of the bear-traps were placed continuously from bottom to top, except the small parts immediately about the hinges.

After Lock and Dam No. 18 were completed, tests for seepage and hydrostatic head were made by drilling several holes through the wall near the middle of the section and observing the rate of filling and height of rise. In most cases, so little seepage occurred that the upward pressure against the base of the wall was believed to be negligible. Only one hole filled rapidly, a full head from the upper pool being possible. Since the blue shale foundation under that wall is of the same nature and quality as the foundation of the adjacent part of the pass, these tests indicated the possibility of a head against the base of some part of the pass masonry; and the stability of the pass may be due to the anchor-bolts. Experience and observation confirm the writer's belief in the importance and advisability of the use of anchor-bolts.

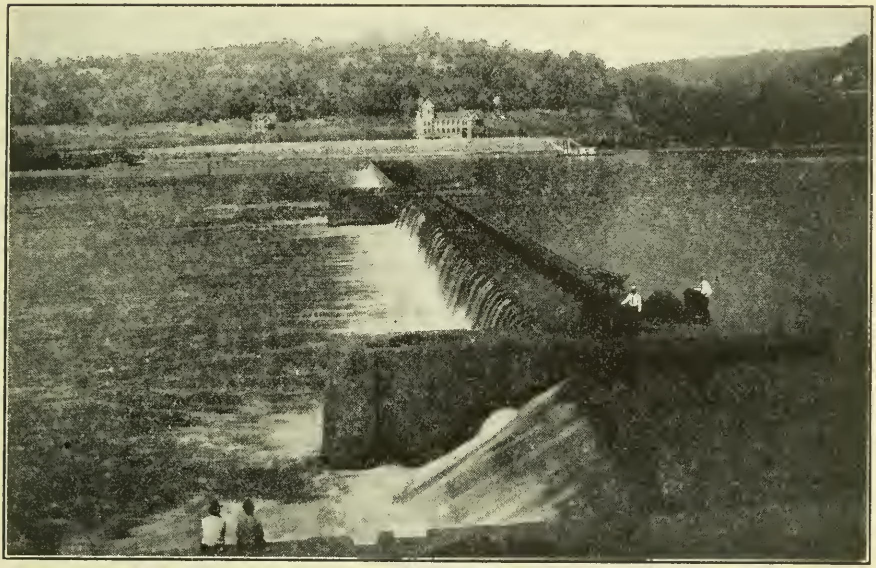


FIG. 8.—VIEW OF COMPLETED LOCK AND DAM NO. 18, OHIO RIVER.

FIG. 9.—VIEW OF MANEUVER BOAT.

In August, 1912, after the dam had been in operation for two years, the bed-rock at the toe of the down-stream face of the pass foundation was examined, and no cutting or wear could be detected. Fig. 8 is a view of the completed Lock and Dam No. 18.

Cost of Masonry and Excavation, Lock No. 18.—A tabulation of estimated quantities, contract prices, and amounts, together with the actual cost of the completed work is given in Table 5. The cost figures were furnished by C. H. Wright, Local Manager for the Contracting Company.

TABLE 5.

Item.	Quantity.	Contract.		Cost to Contractor.	
		Unit price.	Amount.	Unit§ price.	Amount.
Grubbing and clearing, in acres........	5.5	$ 25.00	$ 137.50	$ 25.00	$ 137.50
Lumber, in feet B. M....................	343 614.0	40.00 per 1 000	13 744.56	33.57	11 535.12
Round timber, in linear feet............	35 316.0	0 25	8 829.00	0.17	6 003.72
Common fill. in cubic yards...........	88 010.0	0.27	23 762.70	0.213	18 746.13
Puddle, in cubic yards..................	1 055.0	2.00	2 110.00	0.57	601.35
Stone fill, in cubic yards................	5 842.7	1.50	8 764.05	1.53	8 939.33
Common excavation, in cubic yards....	28 047.9	0.25	7 011.98	0.312	8 750.95
Rock excavation, in cubic yards.......	11 189.6	2.50	27 974.00	1.294	14 479.34
" " " " " *......	27.8	3.75	104.25	Separate cost not kept	
Concrete, in cubic yards................	20 402.6	4.00	81 610.40	3.50	71 409.10
Concrete cut out of wall, in cubic yards.	1.0	5.00	5.00	Cost not kept.	
Paving, in cubic yards†................	4 807.6	3.50	16 826.60	5.65	27 162.94
Curbing, in cubic yards†................	70.3	7.00	492.10	12.00	843.60
Oak timber, in feet B. M................	2 084.0	50.00 per 1 000	104.20	48.40	100.87
Bolt holes, in linear feet................	415.0	0.50	207.50	0.167	69.30
Iron and steel, in pounds...............	163 423.0	0.055	8 988.26	0.0445	7 272.33
			$200 672.10		$176 051.58
Vitrified pipe, 8-in., in linear feet.......	863.0	0.35	302.05	0.045‡	....
" " 12-" " " "	196.0	0.50	98.00	0.045‡	....
Galvanized-iron pipe, 3-in., in linear feet..................................	2 404.0	0.60	1 442.40	0.026‡	....
Galvanized-iron pipe 2-in., in linear feet..................................	2 747.0	0.40	1 098.80	0.026‡	....
Galvanized-iron pipe, 1½-in., in linear feet..................................	110.0	0.40	44.00	0.026‡	....
Iron placed, in pounds..................	106 754.0	0.0075	800.66	....	....
Gravel and spawls, in cubic yards......	961.4	1.00	961.40	....	....
Grand total....................	....	....	$205 429.41	....	....

* Rock excavation less in section than 4 sq. ft. and 10 ft. below low water.

† This was the principal work done in 1905; the cost includes a large amount for superintendence and management.

‡ The cost here given is for labor of laying only; the cost of the pipe delivered on the work was not obtainable.

§ The unit cost to the contractor does not include shipment of plant to work, interest on investment, insurance, cost of bonds, deterioration in plant, or general office expense. In this cost was included all labor, superintendence, and clerical accounts at the work, materials and everything of expense, except cost of machinery moved to this work from other jobs of the contracting company. Most of the machinery was provided in this manner. The cost of improvements to machinery, repairs, and maintenance and some new pieces of machinery were included.

Operation of Dam No. 18.

Land for Lock and Abutment.—When the location of Dam No. 18 had been definitely decided on, 5.5 acres of land were purchased at a fair farm valuation, above the top of the bank on the lock shore, including the banks up and down stream to the ends of the guide-walls; together with 3.1 acres on the abutment shore, for use of construction. Long delay in making purchases after locating

the lock sometimes results in paying two or three times the farm value, or resorting to the expensive process of condemnation.

Although the purchase was quite large, compared with the amount of lands acquired for the up-river dams, it was found that more land was needed. In 1910 the District Officer, Maj., now Col., F. W. Alstaetter, Corps of Engineers, U. S. A., M. Am. Soc. C. E., authorized the parking of all the land between the slope of the lock esplanade and well back of the rear line of the lockmen's dwellings, and further authorized the purchase of several additional acres of pasturage.

The writer believes it is wise and to the interest of the Government to arrange such facilities for employees, in order to supply commodities and give remunerative exercise within easy call of duty. These accommodations interfere in no way with their duties, because during many hours they have nothing else to do except wait for boats.

Lock Houses.—Two residences were built having basements of concrete, first story of brick, second story of terra cotta, tile roof with attic finished for storage, furnace in cellars and equipped for hot air, natural gas for light and heat, hot and cold water, with three rooms on each floor, bath on second floor, and laundry in basement. The buildings complete cost about $7 000 each. They are used by the lock-master and chief engineman with their families. All the other employees live in their own homes and come daily to work. Men who did not live within calling distance of a mile were required to have telephone connection with the lock-master's office.

Power Plant.—The operating power plant for the lock and dam consists of two 80-h.p. gas engines, each being sufficient for operation, thus eliminating as nearly as possible any possibility of stopping traffic through the lock. Each is belted to and operates an air compressor with a capacity of 300 cu. ft. per min. The auxiliary parts are one starting engine, four air receivers, with a combined capacity of 1 500 cu. ft., an air pump, a steel tower and tank on the hillside for water supply to the power house, lock, and dwellings.

The lock-gates are operated from a wire line winch with an air-operating engine having a pull capacity of 50 000 lb. in either direction. Each engine is provided with an auxiliary receiver. Where a reliable fuel supply can be obtained, the gas engine is the ideal power machine for the operation of a lock, since requirements are intermittent, and usually of short duration.

At Dam No. 33, which was opened for service in October, 1921, all the valve jacks and jacks for maneuvering the mitered gates are operated by oil pressure. The oil pump is operated by steam, and when the dam is up, a duplicate oil pump is operated by a water turbine in the river wall, using water from the upper pool, thus providing a duplicate power unit. The use of compressed air is thus reduced to occasional requirements for the bear-trap operation and for signals on the lock walls.

Maneuver Boat.—The maneuver boat is a very substantially built deck barge, 60 by 22 ft., with a cabin 14 ft. wide by 24 ft. long, covering the principal pieces of machinery. The deck when equipped ready for operation stands about 14 in. above the surface of the water and the timber. The principal equipment for the boat consists of one triple-drum reversible hoist engine

with three winches, double 9 by 12-in. cylinders and pony drum for slewing the derrick, rigged with ½-in. wire line; one vertical 40-h.p. boiler; one stiff-leg derrick with boom located mid-deck near the bow; one outrigger sheave projecting from the bow for carrying the ½-in. line used in raising and lowering wickets; one steam capstan near the stern with an engine for operating, which carries the line for maneuvering the boat; a boiler-feed pump, a bilge pump, a steam siphon, and a hand pump. The smaller equipment is a wicket raising pole, an extra heavy raising pole, a wicket tripping pole, pike poles, skiffs and oars, 2-in. manila stern line, two 1½-in. manila side lines, 100 ft. long, several hand lines ¾ in., 1 in., and 1¼ in., one anchor, and one tarpaulin.

The cost of the boat and the principal equipment in 1909 was as follows:

Deck barge, ready for equipment	$3 800.00
Engine and boiler complete	1 525.00
Wire lines for derrick	108.14
Wire rope sheaves, etc.	53.10
Spuds, six	170.00
Duplex piston pump, 9 by 5¼ in.	50.00
Orange peel bucket, 15 cu. ft.	499.00
Total	$6 205.74

An electric generator with incandescent and arc lights, with the necessary auxiliary parts, has since been added.

Maneuvers.—The three principal maneuvers of the lock and dam consist of: (1) operation of the lock when the dam is up for the passage of boats; (2) raising of the dam; and (3) lowering of the dam.

The annual force maintained is ten men, which force is supplemented by several additional laborers when the dam is up during the summer and fall. The annual force consists of one lock-master, three enginemen, one dam-tender and five lock-men. Each is an expert at one of the mechanical trades or other useful work, aside from the duties indicated by his position. With spare parts and materials for the machines and structures, this force maintains the lock and dam and appurtenances without additional help, except extra labor engaged locally.

The ordinary maneuvers of the lock for the passage of boats are the same as those required of locks with fixed dams. The usual time for the passage of a boat through the lock is from 7 to 12 min. The time required for the different operations is about as follows:

Closing gate	1 min. to 1½ min.
Filling or emptying lock chamber	1 " " 4 "
Opening gate	1 " " 1½ "
Departure of boat	4 " " 5 "
Total	7 min. to 12 min.

After the winter floods, or after a summer flood of unusual duration, it requires from 1 to 2 days' time of the entire lock force with a maneuver boat

to remove the deposit from each of the lock-gate recesses, and to clean the gates, engine, and engine pit, and place them in a serviceable condition. It requires a day or more to raise the weir and put the maneuver boat in position to raise the pass. The raising of the pass usually requires from 6 hours to 1 day. Fig. 9 is a view of the maneuver boat raising the pass of Dam No. 1. A wicket prop is being raised with pike pole on butt ready to right the wicket the instant the prop drops over the hurter-step. Since it is desirable both for workmen and navigators of boats to have this maneuver made by daylight, the weir is put in readiness, and the raising of the pass wickets for final closure is usually started in the early forenoon. Raising the bear-traps usually requires only a few minutes by the head of water in the upper pool. The weir wickets are easily "righted up" from the "swing" or raised and put up as desired, if done before there is more than 4 or 5 ft. of head. With from 5 to 10 ft. of head, the work becomes much more difficult.

It is possible to lower the pass in from 2 to 3 hours, but it usually requires from 4 to 8 hours. On very rapid rises, the weir is sometimes lowered at the same time as the pass; but the lowering of the last weir wickets is usually left until the pass is down. The lowering of Dam No. 18 pass usually proceeds from the lock wall to the weir and the raising in the reverse direction. Some dams on the river make these maneuvers in the reverse order.

Maneuvering the Weir.—In 1912, Lockmaster Rowe reported on the maneuver of the dam as follows:

"Ordinarily, we raise the service bridge with the maneuver boat as the river falls and the time approaches for raising the pass.

"When the maneuver boat is in position at the abutment end of the weir, the boom of the derrick is lowered until the main fall is directly over the chain connected with the section of bridge to be raised. A hook constructed so that it will engage with the bridge chain at any point is used on the main fall. One man is stationed in a yawl, whose duty it is to connect this hook with the bridge chain as low down in the water as convenient. This section of the bridge is then raised with the main fall of the derrick, until the end of the apron is on a level with the top of bridge on pier. A 1½-in. manila rope, with an iron hook on the end, is then hooked into the ring on the end of the apron. This rope passes through a snatch-block on the pier back of the starting point, or on preceding section of bridge, then back through fixed sheave on forward end of boat and is pulled with steam capstan. The rope swings the section of bridge back until the bent is perpendicular. The apron is held up at the proper height with the derrick until in position for dropping down over pins in pier or in preceding section. About four sections can be raised with boat in the same position. The boat lies below the bridge with bow up stream. This maneuver requires seven men: One for operating engine, one for operating capstan, one in yawl for engaging hook, two on bridge for connecting up sections, moving snatch-block, etc., and two on deck of boat for handling lines, moving boat, etc. The bridge can be raised in this manner in one-half the time required for raising it with the winch.

"When the bridge is up, the maneuver boat is then moved over to the pass and two crews are organized so that the weir wickets and pass wickets can be raised at the same time. [Fig. 10 shows a wicket-sinking arrangement for weir service bridge for Dam No. 18].

"In raising the weir wickets with the winch, the duties of the men are about as follows: One man for operating the gasoline engine, clutch-coupling

and foot-brake; one for placing chain on wheel and keeping it from getting fouled in the gear; two for moving and clamping car on track, handling chains, etc. The weir wickets are left on swing until they are all up in that position, and then the same crew rights them up with pike poles after the navigation pass is closed.

"By leaving the weir on swing and both bear-traps down, we rarely have more than 2 ft. of head when closing the pass.

"There is other work to be done aside from that mentioned in raising and lowering the dam, sunken logs, boulders, etc., are encountered, props are found to be out of hurters, hurters have to be cleaned out, etc. When these things are encountered, all the members of the crew work to adjust them. One man who handles the catching hook will sometimes dive down and lift a prop over into a hurter by hand, rather than make the maneuver again."

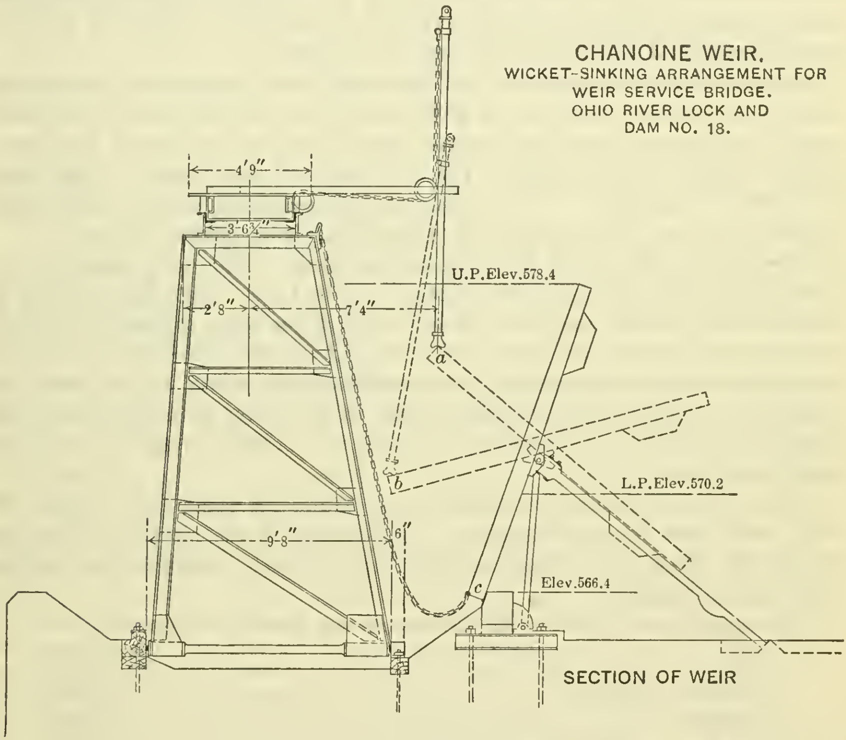


FIG. 10.

Due to the ease of operating the traps and the difficulty of moving the maneuver boat around the traps and their piers, in a dam without a bridge and which has the traps near mid-stream, between the wicket navigation pass and wicket weir, when the dam is up or after raising is started, the lockmen depend almost entirely on the traps for regulating the pool and neglect to use the weir for that purpose, the function for which it was built.

This difficulty makes it now appear that on those dams having abutment shores of ledge rock, or ledge within 10 or 15 ft. of the sill level, a desirable

location for the traps would have been next to the abutment, thereby placing the weir wickets next to the pass wickets.

Except for the excessive cost of the traps, an ideal arrangement would be to abandon the wicket weir and substitute bear-traps having sufficient waterway to regulate the pools for a natural 10 or 11-ft. stage discharge.

In 1914, the writer had the 15-ft. trap in Dam No. 18 cleaned and repainted. His report of this work is as follows:

When unwatering was completed, a deposit estimated to be about 65 cu. yd. was found in the recess under the two leaves. The deposit on the upper side of the area was largely of silt, but on the lower side near the lower hinge, it was principally gravel ranging from the size of a pea to that of an acorn. Much of the gravel was clean washed and lay 2 ft. or more in depth on the recess floor. In all the pockets of the lower leaf, the deposit was from 14 to 18 in. deep, composed of silt, containing little or no gravel.

On the top skin of the lower leaf, from 60 to 70% of the metal was bare of paint, the remainder being fairly well covered with the shop coat. The under side of the lower skin and the exposed metal on the under side of both leaves were practically bare of paint. On the inside of the pockets of the lower leaf, from 80 to 90% of the metal was covered with paint. After being cleaned there was slight indication of the metal being pitted by rust.

The two wooden seals were almost destroyed. The lower flange of the lower end of the easterly girder in the lower leaf was bent from 4 to 10 ft. in front of the hinge; the lower flange of one of the other girders was slightly bent; thirteen girder web-plates were bent, and the two lower ones in the easterly girder over the bent flange, were badly buckled; eleven of the cross web-plates were slightly bent; eighteen plates of the lower skin were bent; two bolts near one of the hinges were out, but no sheared rivets or loose rivet-heads were found.

Since the trap had been operated successfully for some time without the water seals, they were not replaced. The damage to the metal work was not considered sufficient to affect seriously its strength, therefore, no attempt was made to repair it.

The approximate cost for all this work was about as follows:

Labor	$1 158.43
Painting materials	173.01
Lumber	118.48
Supplies, caulking material, etc.	35.00
Miscellaneous	78.57
Gas	85.00
Coal	100.63
Total	$1 649.12

In order to ameliorate the adverse conditions described, the following changes were suggested:

"(*a*) In each of the piers there should be a pump-well, at least 4 by 6 ft., to admit of using a larger pulsometer. Directly under each of the manholes in the lower leaf, next to the piers, there should be a similar sump.

"(*b*) The piers should be long enough at the lower end to give a plain surface bearing for the end coffer-dam needles. About the perimeter of the lower culvert portals there should be a recess with a plain surface at least 6 in. in width, in order to make the bulkhead more easily fitted and more easily caulked.

"(*c*) The greatest danger from the deposit underneath the leaves is believed to be in lifting or holding the lower leaf above its natural position on the floor, thereby throwing undue strains on some of the girders or creating a short lever arm and bringing excessive pull on some of the hinges. This is especially dangerous where the support under the girders is near the lower end hinges. This may be prevented by placing the upper and lower water passages between the bear-trap recess and the culverts close to the hinges. It is also advisable to make those openings from 3 to 5 ft. high instead of 2½ ft. Should this method not entirely relieve the trouble, in new construction a pipe or culvert laid just below the line of the hinges with an opening alongside each hinge leading from the bear-trap recess to the culvert no doubt could be made effective in washing out any deposit which might occur.

"(*d*) In order to clean the pockets of the lower leaf more easily it is desirable to substitute channels and angles for some of the web-plates. The elimination of this method of bracing and the elimination of half the plates would make the cleaning very much easier."

As the writer was not able to find any record of a trap having been unwatered, cleaned, and painted elsewhere, somewhat better progress could be made on another similar job with this experience.

Maneuvering Pass.—The first sixteen wickets of the pass are raised with the maneuver boat lashed to the pier. After they are up, the maneuver boat is laid alongside them, and the raising proceeds as described by the writer, in his report of May, 1912, as follows:

"The head of the boat is brought up so that the front edge of the bow is within a few inches of being flush with the last wicket raised, the boat being held in place by a stern line to the pier, and two side lines made fast to convenient wickets—one near the bow and one near the stern. With the boat thus prepared and held in position, the lockman casts the raising hook to land on the upper face of the wicket to be raised. After striking the wicket it is drawn along it by a ½-in. wire line wound on one of the drums of the hoisting engine, until the hook engages in the handhold at the butt of the wicket. The wicket is then drawn up until the prop is heard to fall into the step of the hurter. At that instant the lockman disengages the raising hook, and another man with a pike pole forces the butt of the wicket down against the pass sill. At the instant the wicket strikes the sill, a third lockman, tending the stern line, releases 4 ft. of slack, and the current carries the boat forward the width of a wicket. At the same time the engine-man takes up 4 ft. of the head side line while the lockman on the head of the boat maneuvers the side line on the winches of the engine. This movement usually requires from 10 to 15 sec. from the time the butt of the wicket strikes the sill. In general, it is not necessary to operate the spuds in either raising or lowering the wickets. During this maneuver the stern spud and upper side spud are raised and hooked up. The lower side spud is left down just far enough to engage the wicket. By so doing, it serves two purposes: The boat is made steady, and as it engages the wicket below the axis, it prevents it going on swing."

In lowering the pass wickets the movements of the boat are a reverse of those described previously. The lockman engages the lowering hook in the upper hand hold of the wicket, and signals to the engine-man to pull on the

line attached to the hook. The instant the lockman hears the prop drop out of the step of the hurter, he disengages the hook, and the wicket, if not obstructed, is carried gently down by the current into position below the sill. At the instant he disengages the hook, the boat is brought in position for lowering another wicket.

The maneuvers of the wickets are often interfered with by obstructions of gravel, boulders, and driftwood. The methods of overcoming these difficulties are only learned by experience.

Water Supply.—The water supply was taken by an air-lift pump from the rear end of the upper gate recess and by sedimentation gave a potable water. At sites where a natural supply is not found, the filter should be constructed at a convenient place in the lock coffer-dam. For Locks Nos. 20 and 33, and for some of the others, filters are constructed in the angle between the upper face of the navigable pass and the river wall.

Signal Lights.—Signal lights are maintained for indicating whether the dam is up or down, and the position of the ends of the river wall and bear-trap piers. The number of lights, their positions, and colors are prescribed by the Engineer of the Light House Department. The lights are carried on standards. Supports of concrete and steel have been tried, but have not yet proven entirely satisfactory. The supports after being submerged and the lights extinguished are a menace to navigation as long as the depth of water is too shallow to prevent boats passing safely over them. During periods of swift current, drift, and ice, it has not been easy to maintain floating supports for carrying the lights. In April, 1915, a passenger steamer hit one of the lower towers on Lock No. 19, sank within a few minutes, and about 17 people were drowned.

Snubbing Posts.—The next greatest menace to navigation are the snubbing posts on lock walls and piers. In March, 1907, a steamer hit the second snubbing post (from head) on the river wall of Lock No. 18 in clear weather, when there was about a foot of water over it, and sank within 15 min. on the head of Neals Island, with several people narrowly escaping drowning. At the time, the water breaking on the nose of the wall clearly marked its position. The light towers and snubbing posts continue to be the greatest source of danger to the navigation of the locks and dams.

Disposition of Drift.—It has been the custom to dispose of the drift by hand or derrick or by letting down one or more wickets or a bear-trap. The writer believes that all big logs and trees should be landed on shore, cut up, and burned, thereby preventing injury to passing boats, or further attention at the next dam below.

The writer wishes to make acknowledgment of courtesies extended by Col. Earl I. Brown, Corps of Engineers, U. S. A., M. Am. Soc. C. E., in charge of the First Cincinnati District, for access to records of his office as supplemental assistance in preparation of this paper.

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PAPERS AND DISCUSSIONS

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THE DESIGN OF AERATION UNITS AND SEDIMENTATION TANKS FOR THE ACTIVATED SLUDGE SEWAGE DISPOSAL PLANT AT MILWAUKEE, WISCONSIN

By Darwin W. Townsend,* Assoc. M. Am. Soc. C. E.

Synopsis

During the last seven years the activated sludge process of sewage disposal has been developed from miniature laboratory models in the first stages of scientific observation to a practical and efficient working process capable of purifying sewage to a high degree.

The development of this process has claimed the attention of sanitarians throughout the civilized world, and promises to continue doing so in the future.

The municipal authorities of many towns and cities in the United States and Europe have investigated and adopted the process as most applicable to the conditions involved in their problems of sewage disposal.

The City of Milwaukee, situated on the western shore of Lake Michigan, and at the junction of the Milwaukee, Menomonee, and Kinnickinnic Rivers, which flow through the city from the north, west, and south, respectively, realized a great many years ago the necessity of preventing the sewage-laden rivers and inner harbor from discharging their ever-increasing filth into Lake Michigan, the source of the city's water supply, and on the bathing beaches on the Lake shore.

In 1914, the then recently created Sewerage Commission established a sewage testing station on Jones Island, at the outlet of the Menomonee Intercepting Sewer, and provided facilities for determining the applicability of the various universally recognized processes of sewage disposal, to the treatment of Milwaukee sewage.

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Engr. of Designs, Sewerage Comm., Milwaukee, Wis.

During the latter part of 1915, the activated sludge process, then recently introduced in England, was given its first trial in tanks constructed at the testing station for this purpose. The results obtained with these tanks and with other equipment subsequently installed, were encouraging, and during the following two years sufficient progress had been made in the development to warrant the Sewerage Commission in adopting the process for the treatment of the sewage of Milwaukee.

In comparison with the older and better known processes of sewage treatment, the activated sludge process demonstrated its superiority in many ways, the most important of which are:

1.—Rate of treatment per unit of area.
2.—Degree of clarification.
3.—Degree of bacteria removal.
4.—Commerical value of the sludge.

This paper deals only with the particular phase of the design implied in the title, namely, the aeration units and sedimentation tanks, the designs for which are fully developed. The designs for the fine screening and sludge de-watering plants are not fully developed, and, therefore, are referred to only casually by the writer.

That the sludge can be successfully de-watered in filter presses was demonstrated at the testing station during 1919 and 1920. Throughout this period, extending from the fall of 1919 to the fall of 1920, two types of filter presses—the leaf type and the plate type—were used almost continuously, and the sludge was de-watered to a suitable consistency for handling in connection with further moisture reduction in rotary dryers.

In the preparation of this paper an attempt was made to select from the voluminous supply of notes, data, and reports in the writer's files, only matter considered pertinent to the decisions made to date relative to the final design of the aeration units and sedimentation tanks for the activated sludge sewage disposal plant of Milwaukee.

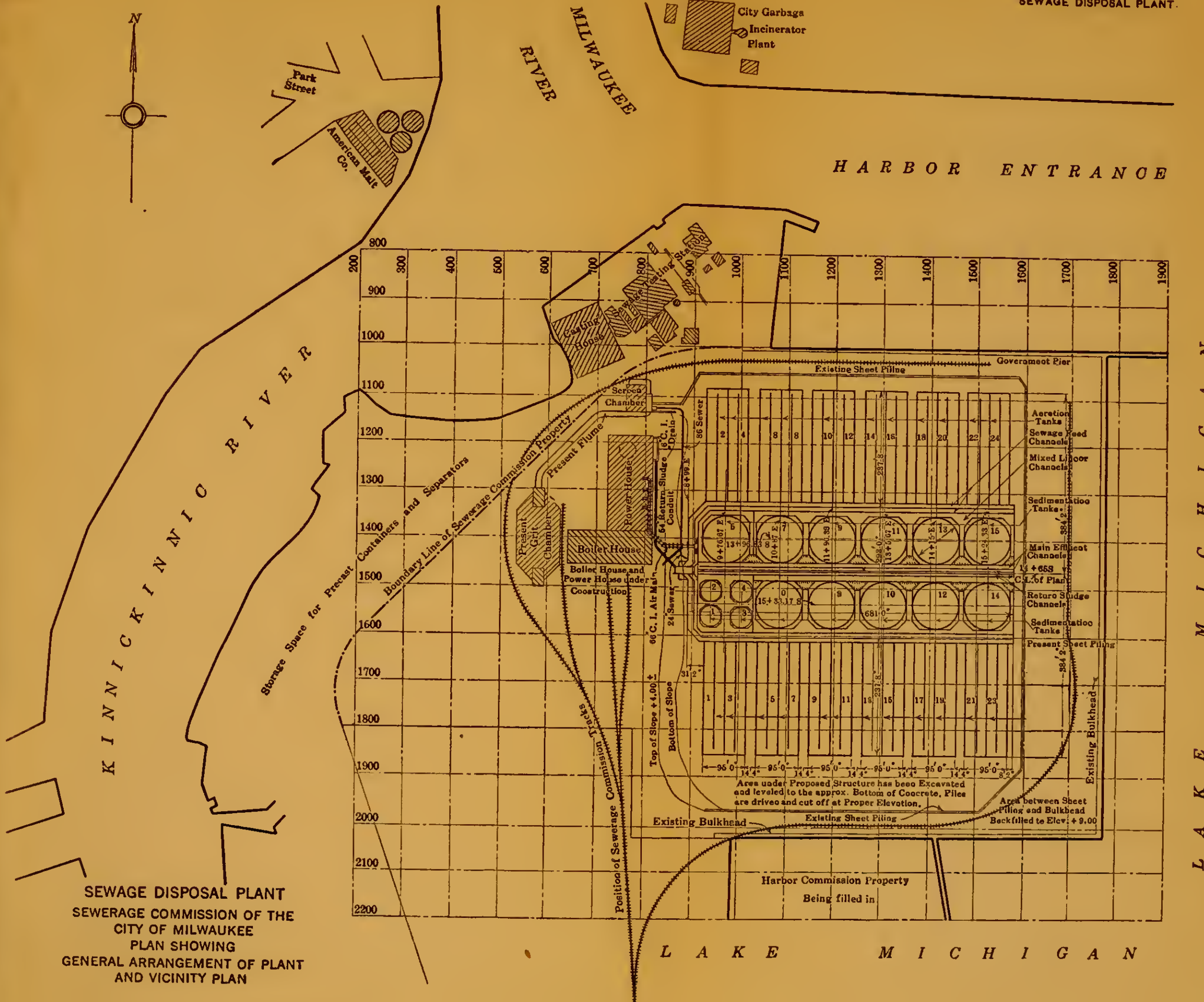
A number of comparatively new terms in sewage disposal literature, applicable, probably, only to this particular process of sewage treatment, will be explained as fully as possible.

The writer is entrusted with the development of designs for the Milwaukee Sewerage Commission, and takes pleasure in presenting this paper, with the hope that it may contribute something to the art of sewage disposal and help at some future time in the solution of problems similar to those on which engineers have been engaged in Milwaukee.

General Arrangement.

The visualized conditions pertaining to the operation of a large activated sludge disposal plant suggested an arrangement of units similar to that of a large mechanical water filtration plant wherein convenience of operation and completeness of control are paramount.

The general idea followed in laying the foundation for the design of the plant at Milwaukee was to secure an arrangement which would provide



SEWAGE DISPOSAL PLANT
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operating galleries immediately adjacent to the rows of aeration and settling tanks and place in them all the necessary appurtenances for the complete control of the air, sewage, and sludge passing through the plant.

Referring to Plate I which shows the entire layout, the plant will be seen to consist of twenty-four aeration tanks and fifteen settling tanks—one row of aeration tanks and one row of settling tanks on each side of the east and west center line of the plant.

The sewage, after passing through the grit-chambers and fine screens, and after receiving the proper quantity of activated sludge at the outlet end of the fine screens, will pass through the mixing channel between the fine screens and the plant and will enter the main feed channel at the extreme western end of the plant. At this point, the flow will divide, half of it going through the two feed channels which supply the aeration tanks north of the plant center line, and the other half going to supply the aeration tanks south of that line. Each aeration tank is separated into two compartments by a baffle-wall, thereby causing a reversed flow. The flow enters the tanks through pipes in the end walls of the west compartments and leaves through pipes equipped with meters at the end of the east compartments. The outlet pipes pass through the two feed channels and discharge into the mixed liquor channels which surround each of the settling tanks on three sides.

The settling tanks take their supply from the mixed liquor channels through submerged gates in the east and west walls of each tank, the effluent from each tank being collected in troughs which discharge into each of the main effluent channels running east and terminating at Lake Michigan. The sludge is withdrawn from the bottom of each settling tank and discharges into the two return sludge conduits which convey it to the return sludge pumps in the northeast corner of the main power house. From these pumps, it is forced under pressure to the point of feed at the fine screen outlet, as previously mentioned.

The plant being designed at the present time is calculated to provide ample treatment facilities for an estimated population of 588 750.

Aeration Units: Rate of Treatment.

Results obtained from the operation of the demonstration plant at the testing station indicate the practicability of operating the aeration tanks at rates as high as 20 000 000 gal. per acre per day without falling below the adopted standards for the effluent. It was decided, however, to adopt 15 000 000 gal. per acre per day as the conservative rate on which to base the design.

The stated rate of 15 000 000 gal. per acre per day applies to the quantity of sewage treated on each net acre of horizontal sewage surface in the aeration tanks only, the settling tanks, channels, and walls not being included in the computed area. When treating sewage at the rate of 15 000 000 gal. per acre per day, in a tank with a 15-ft. depth of liquor and with 20% by volume of activated sludge in the mixture, the corresponding period of detention closely approximates 6 hours.

In computing time of detention, displacement is assumed not to occur in that part of the tank occupied by the sludge. In other words, if a sludge content

of 20% is maintained in the sewage, the volume represented by this percentage of sludge is assumed to occupy space in the tanks permanently and is not available for detention purposes.

Each of the twenty-four aeration units is 236 ft. long, 44 ft. wide, and 15 ft. deep from the liquid surface to the top of the diffuser plates, and based on a rate of 15 000 000 gal. per acre per day, with a sludge content of 20%, will treat approximately 3 580 500 gal. per day.

The volume of each tank is about 156 000 cu. ft., of which 31 200 cu. ft. are reserved for the 20% of returned sludge, leaving 124 800 cu. ft. of space available for the detention of the sewage. The detention period corresponding to 3 580 500 gal. per day passing through a tank the volume of which is 124 800 cu. ft., will be, therefore, about 6 hours and 17 min.

TABLE 1.—Estimated Average and Maximum Rates of Sewage Flow per Day for Disposal Plant Design.

(From 1915 Annual Report.)

Year.	Average flow, in gallons per day.	Average flow, in gallons per day, with storm water.	Maximum flow, in gallons per day.	Maximum flow, in gallons per day, with storm water.
1914.....	50 283 000	51 583 000	75 400 000	113 210 000
1930.....	85 183 000	86 483 000	127 800 000	165 610 000
1950.....	128 775 000	130 075 000	193 200 000	231 010 000

In an aeration tank, the time of detention will vary with the rate of sewage flow and the percentage of sludge maintained in the plant. If sludge is returned at a constant rate, the sewage flow will be the only variable which, of course, will fluctuate through rather wide ranges, as shown in Table 1. However, if the sludge is returned at a rate corresponding to the fluctuating sewage flow, then the detention period, based on an average rate of flow, would be more difficult to determine, owing to the increase or decrease in the flow intensity of both sewage and sludge during a 6-hour period. As an illustration, the sludge and sewage may be entering a tank at a rate corresponding to the sewage flow for the particular time under consideration, and, at the same time, the sewage and sludge leaving the tank would correspond to the flow which occurred 6 hours previously. Returning sludge at a fluctuating rate would require automatic pumping equipment synchronized with the sewage flow. This kind of equipment does not appear to be warranted on account of the fact that returning sludge in this manner contributes nothing to the efficiency of the plant. Owing to the "lag" through the plant, due to the large capacity of the tanks, it is questionable whether the synchronous method of operation could be controlled so as to approximate even the conditions of operation which, at first thought, appear to be the most desirable. As inferred previously, the Milwaukee plant is being designed to operate on a constant supply of returned sludge. This is based on the theory, which has been demonstrated successfully in the testing station plant, that the constant supply of sludge carried, is aerated sufficiently during the low night flows, so that the plant will treat successfully the peak flow of the day without becoming impoverished in the effort. In other

words, the designs are based on a minimum constant supply of well aerated sludge, rather than on a larger and variable quantity aerated probably to a lesser degree of activity.

Each aeration unit is designed for a reversed or two-way flow, and the total length of travel is about 475 ft. The sewage which has been previously mixed in the feed channels with the sludge, enters each tank through two 30-in., gate-controlled, inlet pipes in the end wall and below the sewage surface and leaves the tank through a 24-in. outlet pipe equipped with a Venturi meter. The outlet pipe discharges into the mixed liquor channels which supply the settling tanks. The liquid level in the tanks is maintained practically constant by an overflow weir 12 ft. long, which forms one side of an outlet box connecting directly with the outlet pipe.

Figs. 1 and 2 show the general features of an aeration unit. The ratio of the square feet of diffuser area to square feet of horizontal liquid surface is approximately 1 to 4. Each of the cross-containers holds nine diffuser plates and each of the containers running lengthwise through the centers of the two compartments in each unit, holds seven plates. The containers running lengthwise form a gutter, in each compartment, to be used for drainage purposes when emptying a tank. Seven plates are used in each of these containers for the purpose of facilitating the standardization of the air-piping.

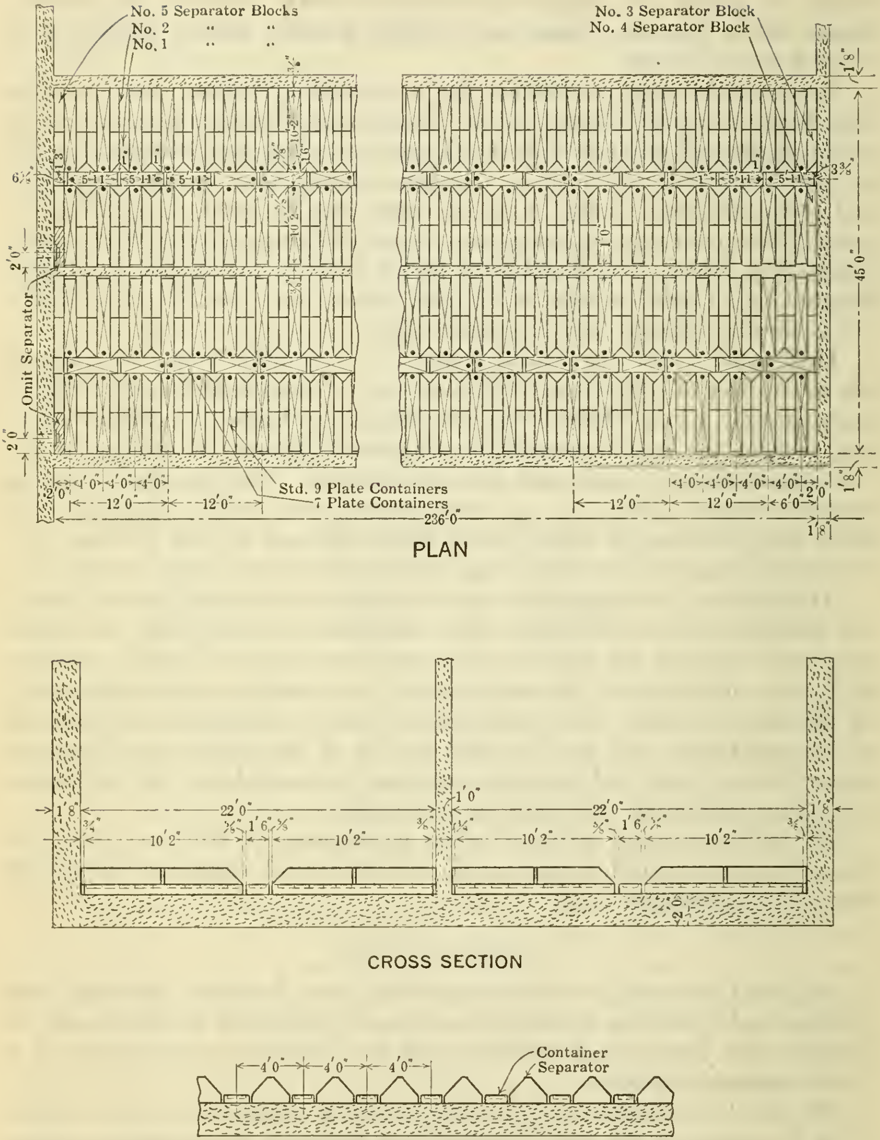
The supply of air to each unit enters at the end adjacent to the side operating galleries, through a 12-in. pipe, and is measured by an air meter. The 12-in. pipes pass through the gallery walls, run downward, and branch into two 10-in. pipes directly over the center of the 12-in. partition walls in the center of the aeration units. The 10-in. air-lines are carried the entire length of each compartment and are supported on top of the precast container separator blocks. Each diffuser-plate container is supplied with air through a 1½-in. pipe connecting with the 10-in. air-header.

All the information pertinent to the performance of the tanks is plainly set forth on the recording mechanism, and the control valves are within easy reach of the operator.

Settling Tanks.

As stated previously, an aeration unit has great flexibility, and high rates of flow can be maintained without impairing the character of the effluent. A settling tank likewise has flexibility, but of a different character and to a lesser comparative degree.

The limit of the capacity of a settling tank is reached for a given sludge, when the sludge in the tank is carried over the sides of the effluent troughs and out with the effluent. Experience in operating settling tanks at the testing station led to the adoption of 1 600 gal. per sq. ft. per day as the safe rate on which to base the number and size of tanks. This basic figure represents the number of gallons of sewage which can be settled every 24 hours on each square foot of horizontal liquid surface in the tanks, and does not include the return sludge in the mixture which enters the tanks. Therefore, when carrying 20% of sludge in the plant, the total volume of liquor entering the settling tank per square foot of surface area is 2 000 gal. Of this volume



236	9 Plate Containers per Tank	5664 for Total of 24 Tanks
78	5 " " " "	1872 " " " " "
232	No. 1 Separators " "	5568 " " " " "
232	No. 2 " " "	5568 " " " " "
10	No. 5 " " "	240 " " " " "
2	No. 4 " " "	48 " " " " "
2	No. 3 " " "	48 " " " " "

SEWAGE DISPOSAL PLANT
SEWERAGE COMMISSION OF THE
CITY OF MILWAUKEE
PLAN SHOWING
CONTAINER & SEPARATOR SETTING
IN AERATION TANK

FIG. 1.

1 600 gal. represent the sewage flow and the remaining 400 gal., the 20% of activated sludge.

Table 1 shows that the average and maximum expected flows for 1930 are 85 183 000 gal. per day and 165 610 000 gal. per day, respectively, the maximum flow being about 94% greater than the average flow. This great difference

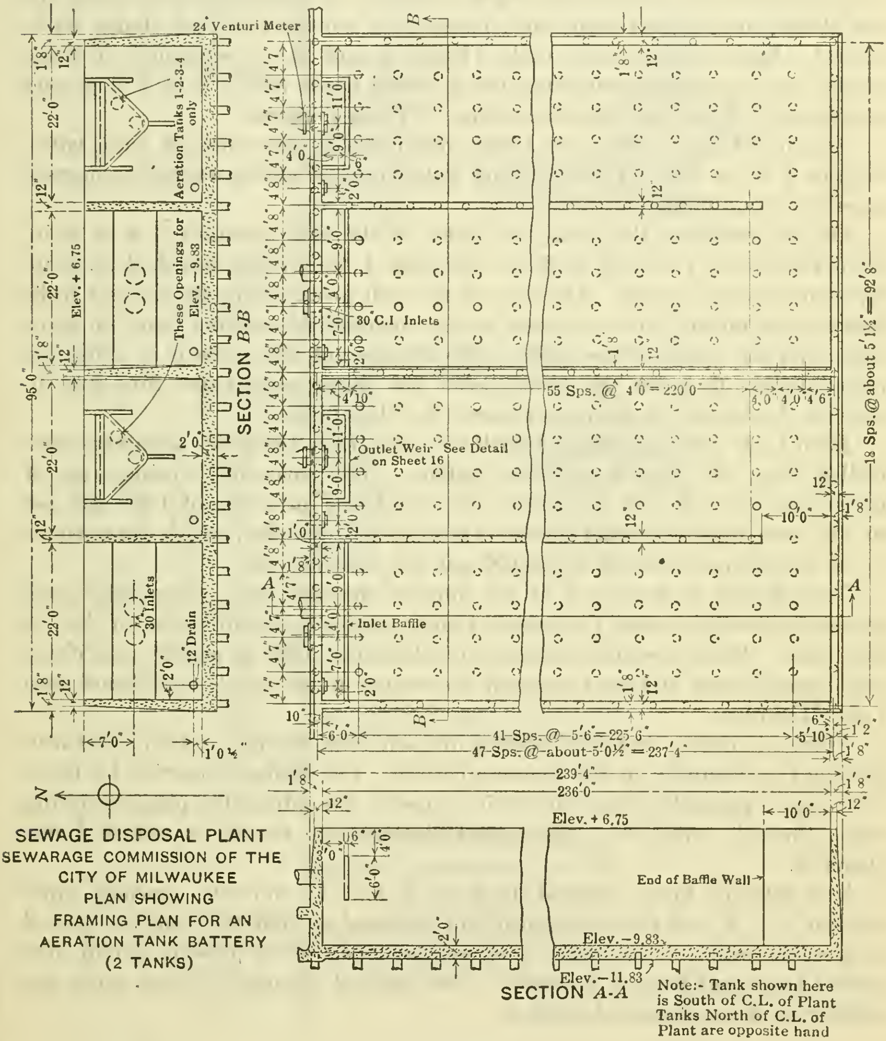


Fig. 2.

between the average and maximum flow makes it necessary to provide settling tanks for the maximum flow rather than for the average, because if the settling tanks were proportioned to the average flow on a basis of 1 600 gal. per sq. ft., during the maximum flow this amount would become 3 100 gal.

per sq. ft., which is greatly in excess of the safe rate. Rates as high as 2 000 gal. per sq. ft. have been obtained in the tanks at the testing station and a similar rate in the large tanks now being designed can reasonably be expected. However, a study of the settling-tank data, indicates that the rate decided on is conservative and on the side of safety.

A depth of 15 ft. from the liquid surface to the inside bottom of the tank was adopted and considered the depth necessary to allow adequate storage for the sludge during maximum flow, based on a constant rate of sludge withdrawal. Each of the eleven tanks (Plates I and II) is octagonal in shape at the top, the corners and sides being sloped down with a 2 to 1 slope and converged to form the circular bottom, 98 ft. in diameter.

The mixed liquor enters the tanks from opposite sides through eight gates, 8 ft. by 9 in. in size. There are four gates on each side, arranged to operate together or individually.

On the inside of the tank, the center of the gate openings is 4 ft. 6 in. from the top of the tank walls, or allowing 1 ft. for free-board, 3 ft. 6 in. from the sewage surface. The part of the wall above each gate forms a baffle between the mixed liquor channels which surround the settling tanks on three sides, and the inside of the tanks. The function of this baffle is to cause the mixed liquor to enter the tanks below the upper clear-water zone and to shorten the length of downward travel for the sludge.

Each tank is to be equipped with complete Dorr thickener apparatus controlled from the central operating gallery. The horizontal surface area of the sewage in each tank is 8 550 sq. ft., and, based on a rate of 1 600 gal. per sq. ft., each tank will treat about 13 680 000 gal. per day, which corresponds to an approximate rate of 68 000 000 gal. per acre per day.

The effluent is drawn off at the surface through three rectangular steel troughs extending across the tanks at right angles to the direction of flow in the tanks. These troughs discharge into the main effluent and by-pass channels running east and west through the center of the plant, and thence into Lake Michigan.

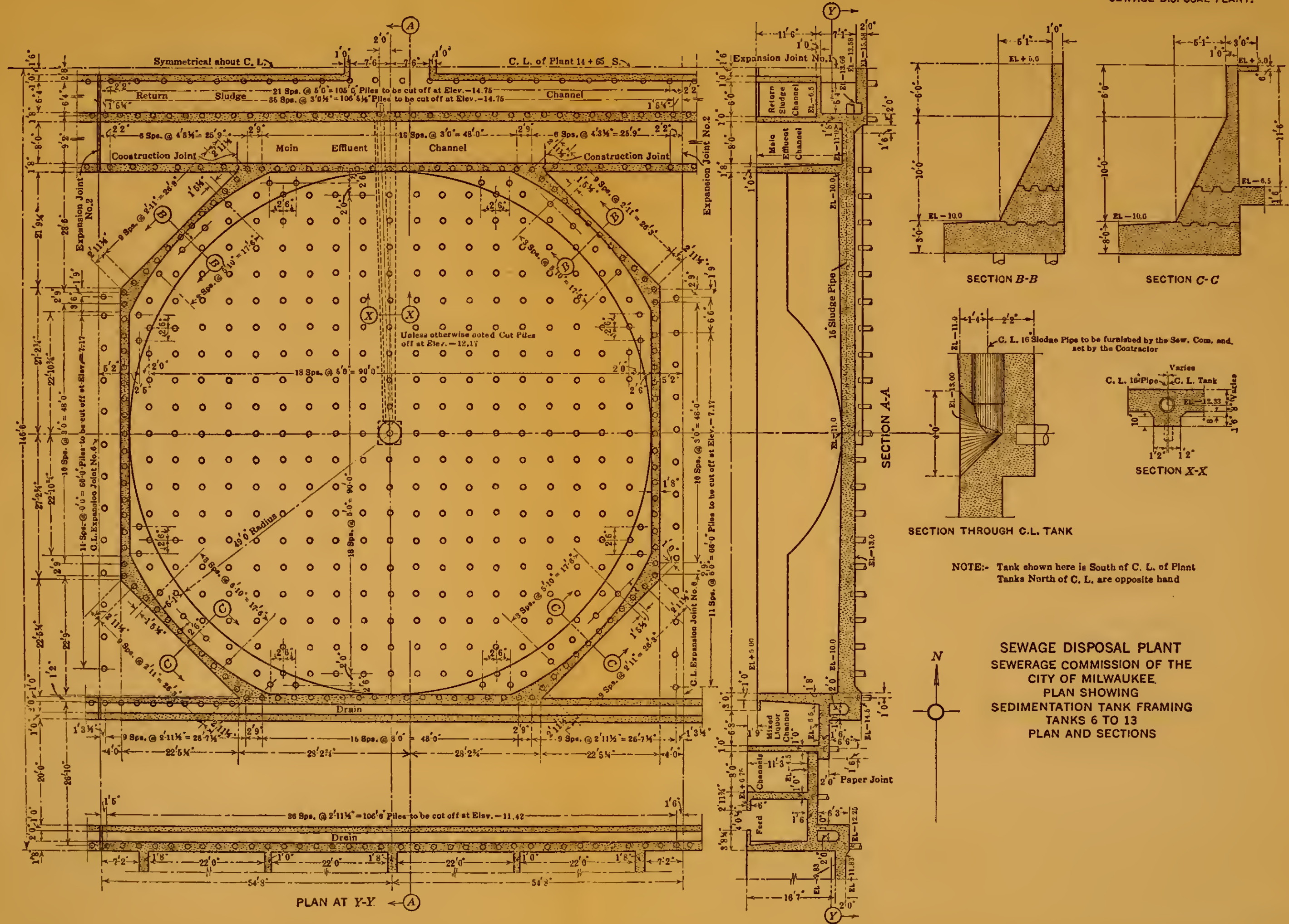
Sludge is drawn from the bottom of each tank through a 16-in. cast-iron pipe laid horizontally in the concrete bottom. The sludge is carried by 14-in. riser pipes, vertically, from the 16-in. pipes to the adjustable pipe-regulating arms, through which it is discharged directly into the main return sludge channels.

The settling tanks marked 1, 2, 3, 4 and 5, and the aeration units marked 1, 2, 3, and 4, are designed and arranged so that they can be isolated to serve as units for the special treatment of sludge to be pressed, should such special treatment become necessary. The general features of these tanks are similar to those already described.

Channels.

The ratio of diffuser-plate area to the area of the sewage surface in the feed and mixed liquor channels is approximately the same as that in the aeration tanks, about 1 to 4, the return sludge channel being provided with a ratio of about 1 to 6.

PLATE II.
PAPERS, AM. SOC. C. E.
JANUARY, 1922.
TOWNSEND ON
ACTIVATED SLUDGE
SEWAGE DISPOSAL PLANT.



SEWAGE DISPOSAL PLANT
SEWERAGE COMMISSION OF THE
CITY OF MILWAUKEE.
PLAN SHOWING
SEDIMENTATION TANK FRAMING
TANKS 6 TO 13
PLAN AND SECTIONS

The effective depth of all channels is 10 ft. This depth permits the drainage system of the plant to be constructed under the channels, practically no additional excavation being required.

The value of the aerated channels, as aeration units, was considered at length, but owing to the variables, such as quantities, velocities, length of travel, time of detention, etc., which entered into the problem, it was decided finally to credit to the aeration plant as a safety factor whatever benefits were derived from aeration in the channels.

The feed channels—two on each side of the plant at the head of the rows of aeration tanks—are provided in duplicate in order to insure against shutting off parts of the plant should it become necessary to drain a channel for the purpose of making repairs. All feed channels are designed for the anticipated 1950 flow.

The mixed liquor channels are arranged so that sections can be cut out of service and drained for the purpose of making repairs, etc. Each section is comparatively small and with only one section between two settling tanks out of service, it is impossible to cut out of service more than one entire tank. Owing to the probable infrequency of having to make repairs in the mixed liquor channels, stop-planks are to be used instead of sluice-gates. All the feed channels and mixed liquor channels are 8 ft. wide.

The return sludge channels, each 6 ft. wide and 11 ft. deep, are in duplicate for reasons already mentioned in connection with feed channels. They receive the discharge of sludge from the settling tanks and will contain a maximum depth of 5.5 ft. of sludge, which will permit visual inspection of the sludge being discharged from each settling tank. At the extreme west end of the plant, the two channels, each of which are equipped with sluice-gates for control purposes, unite into a small forebay at the head of a 54-in pressure conduit which carries the sludge to the return sludge pumps.

The two main effluent channels, each 8 ft. wide and 16 ft. deep, for obvious reasons, are not equipped with diffuser plates. The depth of water in these channels will depend on the stage of the water in Lake Michigan. At Elevation 0.00 the depth will be about 11 ft. The parts of the channels between the end of the plant and the outer bulkhead are designed as pressure conduits in the form of inverted siphons and at a sufficiently low elevation to permit of future plant extensions directly on top. The discharge from the plant will occur at the outer face of the bulkhead in about 12 ft. of water.

Plant Hydraulics.

During the early stages of the design of the disposal plant, the engineers were confronted with the fact that to convey large and fluctuating quantities of sewage in and around the proposed plant and to and from the various units, and, at the same time, provide self-cleansing velocities for a mixture of sewage and activated sludge, would require head greatly in excess of that available.

It became necessary, therefore, to devise methods whereby satisfactory flow conditions could be obtained and the hydraulic losses confined within the fixed limits. Equipping all channels conveying sewage mixed with activated sludge

with diffuser plates, and supplying sufficient air (approximately 1 cu. ft. of air per square foot of diffuser plate per minute) for proper agitation and the prevention of deposition of solids, appeared to be the most practical solution, and was adopted. Besides affecting a substantial reduction in loss of head in the main feed channels, this method possessed the additional advantage of insuring an intimate mixture of sewage and sludge prior to its entering the aeration units.

Following the determination of the major items connected with the design of the plant, such as the most desirable arrangement of units, channels, etc., also flow intensities, size of units, and operating facilities, the problem of analyzing flow conditions and computing and distributing hydraulic frictional losses was considered as follows: To proportion all channels, conduits, pipes, gate-openings, weirs, and sewage-measuring apparatus in the most advantageous manner, confining the total frictional loss through the plant to 4.25 ft., based on maximum assumed conditions of flow hereinafter fully described. This total hydraulic loss represents the difference between the hydraulic elevation of the sewage at the head of the fine screen tail channel, which is +7.25, and the elevation of the assumed high water in Lake Michigan which is +3.00, based on city datum.

The determination of frictional losses through the fine screens, grit-chambers, coarse screen house, and connecting channels, will not be discussed, as it is outside the scope of this paper.

Elevation + 3.00 which was used as the maximum stage of the water in Lake Michigan, was determined from an thorough study of Lake level records taken over a period of fifty years, and although it is questionable whether this maximum stage will repeat and continue over an extended period. it is believed that the use of this elevation will insure the uninterrupted operation of the plant against all except the most extraordinary and unusual occurrences. For several years past, the Lake level has fluctuated between Elevations 0.00 and — 1.00.

Mixing Channel.—The plant described in this paper is assumed to start at the head of the fine screen tail channel, which is the point of application of the activated sludge to the sewage flow and also the point of beginning for channels equipped with diffuser plates. All channels leading up to this point, and also the main by-pass channel which is directly beneath the main sewage channel and extends throughout the entire length of the plant, are not equipped with diffuser plates for obvious reasons.

The part of the channel between the fine screens and the gate-house at the plant entrance (the channel between *A* and *B,* Plate I), and which is termed the mixing channel, is 9 ft. deep and 14 ft. wide and is equipped with diffuser plates in the ratio of 1 to 4, as are all the other channels except those conveying sludge from the settling tanks.

The initial mixing of sewage and returned sludge occurs in this channel prior to its diversion into and through the four feed channels which supply the aeration units. This channel is proportioned to accommodate a maximum flow at the rate of 231 010 000 gal. per day, which is the estimated ultimate capacity of the 1950 plant, plus 40% of returned sludge, based on the esti-

mated 1950 average flow of 128 775 000 gal. per day, making a total of 316 860 000 gal. per day. The 40% of returned sludge referred to, will be explained later under the heading, "Return Sludge Channels."

The following values of Kutter's n were used for the determination of frictional losses:

$n = 0.013$ for pipes.
$n = 0.020$ for aerated channels.
$n = 0.015$ for unaerated channels.

Head losses through gates, openings in walls, and at the entrance to pipes, in most instances, have been based on velocity and entrance-head determinations, the entrance head being taken usually as one-half the velocity head, due credit being given wherever feasible to the velocity of approach.

Considerable uncertainty existed regarding the selection of a proper friction coefficient for aerated channels, owing to the character of the bottoms which, when equipped with diffuser containers and container separators, will offer considerable resistance to the flow, and also owing to the upward passage of diffused air through the mass of sewage, with the attendant possibility of setting up counter currents.

The consensus of opinion, however, was that the coefficient adopted ($n = 0.020$) at least would give results on the side of safety.

Gate-House.—The gate-house, so-called because in it are four, 6 by 10-ft. control sluice-gates, one at the entrance to each of the four sewage feed channels, is located at what is called herein the entrance to the plant and also at the terminus of the mixing channel. Mixing is continued, however, throughout the entire length of each feed channel.

For reasons explained previously the feed channels are in duplicate. During the time the channel is out of service, the aeration tanks will take their supply from the duplicate. For the purpose of assuming a maximum condition on which to determine the loss of head through the head-gates, it was considered possible that the maximum flow of sewage might occur at a time when sludge was being returned to the plant at double the normal rate, at which time two of the feed channels, one on each side of the plant, were out of service, leaving the two remaining active channels to pass the entire flow.

This assumed condition may appear to be severe, but as the total loss involved was not considered to be excessive, no material advantage would have resulted from the adoption of less severe conditions.

Feed Channels.—Each of the four sewage feed channels is 8 ft. wide and 10 ft. deep (depth of sewage), and, under normal plant operation, all of them will be in use at the same time.

Each of the twenty-four aeration units is equipped with duplicate inlet pipes, 30 in. in diameter, and sluice-gates, each inlet pipe taking its supply from one of the duplicate feed channels.

The total length of each pair of channels is about 790 ft. for the 1930 plant and 1 120 ft. for the 1950 plant, it being assumed that the extension required to accommodate the estimated sewage flow for 1950 will consist of

twelve additional aeration units and six sedimentation tanks, or an increase of about 50% of the capacity of the plant designed for the 1930 period.

The maximum conditions of flow on which loss of head determinations was based, are those described previously, in connection with the functions of the gates in the gate-house. The frictional loss was computed on an increment basis, that is, the total quantity carried in the channel was decreased at uniform intervals throughout its length by the quantity supplied to each aeration unit, and a separate computation was made for the decreased flow in each succeeding increment.

The reason for considering the channels immediately adjacent to each row of aeration tanks in determinations for the loss of head, was that the cross-section of the channel is restricted by the 30-in. inlet pipes which connect the duplicate feed channel to the aeration units, and the loss of head would be slightly greater in this channel than in the duplicate, on account of this restriction.

Aeration Units Nos. 1 and 2 were assumed to be out of service for the purpose of simulating a possible condition in operation whereby the flow, which under ordinary operation would enter and pass through Units Nos. 1 and 2, would be required to pass to Tanks Nos. 3 and 4 and thereby cause a small head loss which would not occur with Units Nos. 1 and 2 in service.

Aeration Units.—Each of the twenty-four aeration units is designed on the basis of treating sewage at an average rate of 15 000 000 gal. per acre per 24 hours for the estimated 1930 flow.

Due to the fact that this rate is conservative and that it is possible to operate safely at rates to and including 20 000 000 gal. per acre per day, it is to be assumed that the aeration plant would be operated to its limit before new units were added to accommodate future conditions of increased flow. This assumption indicates the necessity for basing hydraulic loss determinations on the maximum flow conditions existing when operating at a rate of 20 000 000 gal. per acre per day instead of on similar conditions for a rate of 15 000 000 gal. per acre per day.

When operating on an average rate of 20 000 000 gal. per acre per day, an aeration unit will treat approximately 4 774 000 gal. per day; the total quantity of the liquor entering the tank daily through the two 30-in. inlet pipes, including 20% of return sludge, is approximately 5 967 500 gal.

The maximum daily rate of flow for the 1930 period, as shown in Table 1, is about 94% greater than the average flow, which means that the peak flow would be at the rate of 9 261 600 gal. per day. The total quantity of liquor passing through the tank at this rate, including return sludge at the normal rate, would be about 10 455 100 gal. It is on this latter quantity that the loss of head through the 30-in. inlet pipes which connect the feed channels and aeration units, was determined; and for the purpose of establishing a maximum condition, this total flow was assumed to pass through one 30-in. inlet only, that connected with the feed channel farthest removed from the aeration units. The head loss incurred in the passage of the liquor through the aeration units is negligible.

The outlet end of each aeration unit, as described previously, is equipped with an overflow weir, and possesses suitable adjusting facilities for obtaining the proper setting. The flow passing over this weir discharges into a forebay which is connected to the mixed liquor channel by a 24-in. Venturi meter equipped with a sluice-gate, and all the necessary apparatus for measuring and recording the flow leaving the unit. With the facilities thus provided for measuring the flow, each aeration unit should be susceptible to close regulation and reasonably complete control.

The fact is recognized that although each and every aeration unit is designed and will be constructed in precisely the same manner and, theoretically, should treat like quantities under given conditions, it is quite probable that each unit will have its own peculiar characteristics, and to secure the most efficient results, will have to be operated accordingly. The entire field of meters and measuring devices for measuring liquids was thoroughly investigated before the Venturi meter was finally adopted.

Mixed Liquor Channels.—The hydraulic losses occurring in the mixed liquor channels are derived from the assumption that a quantity of sewage equivalent to the rated capacity of one sedimentation tank will be required to pass through two of the 4 by 6-ft. openings in the partitions which are placed at regular intervals in the mixed liquor channels for the purpose of isolating sections of the channel by the use of stop-planks.

The loss of head caused by the actual flow of sewage in the channels, which are 8 ft. wide and 10 ft. deep (depth of liquor), is practically negligible because of the frequency of the points of discharge from the aeration units, resulting in short lengths of travel and small quantities, as compared with the conditions of flow and quantities carried by the feed channels.

Based on conditions creating loss of head alone, it would have been possible to use a narrower channel for the mixed liquor; but the relative importance of maintaining the elevation of the surface of the liquor in all parts of the channels as nearly constant as possible for ordinary conditions of operation, was deemed of greater moment than the small saving in money which could have been effected through the use of smaller channels.

Sedimentation Tanks.—The rated capacity of each of the 98-ft. sedimentation tanks, as mentioned previously, is 13 680 000 gal. per day. This quantity, together with the return sludge content, will enter each tank through the eight 8 ft. by 9-in. sluice-gates, four each on opposite sides of the tank. With the gates fully open, the frictional losses when passing the quantity mentioned will be negligible.

There is a remote possibility that some manipulation of gates will be required to take up slight differences in the elevations of the edges of the effluent trough weirs of the sedimentation tank, and the surface of the sewage in the mixed liquor channels. A small allowance in head, therefore, has been made for a possible condition requiring throttling of the gates.

Effluent Troughs.—The top edge of the weir plates will be set at the proper elevation and leveled when the tanks are first placed in service.

Theoretically, assuming that the flow over each of the six weirs in a tank would be equal to one-sixth of the total flow through the tank, the

corresponding depth of flow over each weir would be equivalent to that produced by 13 680 000 gal. passing over a weir, 588 ft. long, or about ⅝ in. It is questionable whether the theoretical conditions cited would obtain in the case of the three troughs and, in view of the lack of information pertinent to the possible skimming action of multiple troughs, it was thought best to make a somewhat greater allowance in the quantity passing over both weirs of the middle trough. Therefore, an allowance of 50% was made, in lieu of the 33⅓% used in the theoretical trial calculation.

Effluent Channels.—The two effluent channels which are parallel and adjacent to the return sludge channels, on opposite sides of the center line of the plant, receive the effluent directly from the ends of the effluent troughs and convey it to an outlet chamber at the eastern bulkhead, as indicated on Plate I, where it is discharged directly into Lake Michigan through submerged openings which are in duplicate.

The channels are to be constructed as open channels as far as the eastern end of the 1930 plant and, from this point to the Lake, as pressure conduits.

The function of the pressure conduits, besides that of conveying the effluent to Lake Michigan, is twofold: First, to minimize in the open channels the effects due to "swell" and wave action caused by on-shore winds; and, second, to permit the continuance of the construction of future plant in an easterly direction.

It is intended that the effluent from the future extensions to the plant shall flow west instead of east, as in the 1930 plant, and discharge into the submerged chambers provided at the entrance to the pressure conduits, the latter being proportioned to accommodate the maximum estimated 1950 flow.

Each of the effluent channels is 8 ft. wide and 16 ft. deep (total depth), and each of the effluent pressure conduits is 8 ft. wide and 5 ft. deep.

By-Pass Conduit.—The by-pass conduit which begins at the terminus of the riser shaft of the intercepting sewer in the coarse screen house, is to be constructed directly beneath the main sewage conduit and will extend throughout the length of the plant, as mentioned previously, affording by-pass facilities for the coarse screen house, grit-chamber, and fine screens. It will also connect with the two effluent channels at a point beneath the mixing channel at the gate-house.

The maximum loss of head in the effluent channels and pressure conduits will occur when all the sewage is by-passed around all the aeration units and sedimentation tanks (a condition which it is hoped will never exist), but as the loss of head due to this condition would occur at the time when the plant would be out of service, the head losses here considered and adopted are those resulting from the determinations based on the maximum discharge of effluent from the sedimentation tanks.

Sedimentation Tanks Nos. 1, 2, 3, 4, and 5, at the western end of the plant, were assumed to be out of service in making the determination for loss of head.

Return Sludge Channels.—The head loss in the two return sludge channels is entirely separate and apart from the losses which effect the flow through

the plant, and was given separate consideration from the standpoint of conserving the head and thus reducing the lift for the return sludge pumps.

Each sedimentation tank is equipped with two adjustable discharge pipes, 14 in. in diameter. The double discharge feature affords facilities for discharging the sludge into either of the channels.

It is not planned to operate both discharge pipes at the same time, but the design does contemplate the use of both channels at all times, except when it might become necessary to replace a broken filtros plate, repair a pipe, or perform other work of a similar nature in one or the other of the channels.

The assumed condition producing the maximum loss of head will occur when one of the channels is out of service and sludge is being withdrawn from each tank at double the normal rate, and the total quantity is being carried in one channel. The calculation for loss of head was based on this assumed severe condition in order to determine the lowest possible elevation to be used as a basis in fixing the extreme lower limit for the lift for the return sludge pumps. The total length of channel considered in the determinations for loss of head is equivalent to that required to extend to the extreme eastern limits of the 1950 plant.

The aerated return sludge channels terminate at the gate-house, and the sludge carried by them is discharged at this point into an unaerated forebay located at the entrance to an unaerated pressure conduit. This conduit (54 in. in diameter) is proportioned so that the expected minimum flow of sludge through it will create a velocity somewhat in excess of 2 ft. per sec. for the 1930 quantity. The flow conditions on which the head losses are based are the same as those described for the channels.

The return sludge pumping equipment will consist of three motor-operated centrifugal pumps, each capable of pumping sludge at rates of 6 000 000, 9 000 000, and 12 000 000 gal. per day. It will draw its supply from the suction well mentioned previously and force it through a 48-in. cast-iron pipe equipped with a Venturi meter to the head of the fine screen tail channel (mixing channel), where it will be discharged through multiple outlets into the sewage entering the plant.

The sludge to be pressed, or waste sludge as it is called, will be taken from the 48-in. force main, or directly from the aeration or sedimentation tanks which may be reserved for the special treatment of waste sludge, and conveyed through a conduit to the sludge de-watering plant.

Sludge Draw-Off Pipes.—Sludge is to be drawn from the sedimentation tanks by means of hydrostatic head and, unless the actual operation of the plant for a period of time shows indications to the contrary, it will be withdrawn at practically a constant rate throughout each 24 hours.

Although the designs are based on a constant sludge return of 20% and facilities are provided at the same time in the sludge draw-off pipes and in the sludge pumping equipment for a variable rate of sludge return, it should not be inferred that a variable rate of return is contemplated.

The basic figure of 20% and the quantity of sludge corresponding thereto are used in the sense that they reprcsent a probable high average rate, possibly close to the rate which, in actual operation of the plant, may prove to be

the maximum required. Seasonal changes, as applied to the character of the sewage, may indicate the necessity for varying somewhat the rate and percentage of sludge return and, in the light of past experience, in connection with the operation of the testing station plant, the indications appear to be that the basic figure of 20%, if varied at all, will be reduced rather than increased.

The facts leading up and entering into the determination of necessary provisions relative to adequate and proper flexibility for devices and apparatus used in connection with the manipulation of return sludge, can be summed up, as follows:

First.—Approximately seven years will elapse between the time of placing the plant in operation and the 1930 period for which it is designed.

Second.—How closely the actual sewage flow in 1930 will correspond to that which has been estimated, is problematical.

Third.—The actual rate or rates of returning sludge can be determined definitely for the sewage flow from the entire city only after the plant has been placed in operation.

Fourth.—There may be occasions, possibly periods of short duration, when sludge will have to be drawn from the tanks at excessive rates. This may be required in order to lower the sludge level in one or more, or possibly all, of the tanks. The likelihood of this condition arising would appear to depend largely on the efficiency of the operation resulting from the personal equation.

The draw-off pipes are 16 in. in diameter on the horizontal, and 14 in. on the vertical run, except those for the 43-ft. tanks which are 8 in. in diameter, horizontally and vertically. There is a cone-shaped entrance to the 16-in. pipes in the bottom of each tank, at the center, where the sludge which has been deposited on the bottom and which has been brought to the center by the spiral ploughing action of the Dorr thickeners, enters the draw-off pipes and is carried to the return sludge channels by hydrostatic pressure.

The quantity of sludge being withdrawn is controlled by the difference in head between the elevation of the sewage surface in the tanks and that of the ends of the adjustable 14-in. discharge pipes which are to be operated from floor stands through the medium of worms and circular racks.

In selecting the proper size for the draw-off pipes, the determining factors were the minimum velocity and the maximum loss of head, the minimum velocity being established at 2 ft. per sec. and the maximum loss of head at 3½ ft. An allowance of 1 ft. was made between the centers of the discharge pipes and the maximum elevation of the sludge surface in the return-sludge channels, the total distance from the liquid level in the sedimentation tanks to the maximum liquid level in the sludge channels being established as 4½ ft. This allowance will permit unobstructed visual inspection of the flow of sludge from the discharge pipes, and the depth of sludge in the sludge channels, namely, 5½ ft., referred to previously, is sufficient to submerge properly the entrance to the sludge conduit in the forebay, at the western end of the channels.

If all the sedimentation tanks are placed in service during the early years of the plant's operation, the indications are that velocities slightly less than 2

ft. per sec. will obtain in the 16-in. pipes. If, on the other hand, as a matter of operation, the number of tanks in use for a given flow is proportional to the flow, based on the practical limit of the tank's capacity, it would appear reasonable to assume that the pipe velocities would be susceptible to the same range of control which would obtain when all the tanks are in service and operating on the flow for which the plant as a whole is designed.

The 16-in. pipes are to be cast in the concrete forming the floors of the sedimentation tank and are sufficiently large to accommodate the maximum assumed rates of sludge flow based on sedimentation rates considerably in excess of 1 600 gal. per sq. ft., without causing the frictional losses to exceed the fixed limit. The 14-in. vertical pipes and adjustable discharge pipes which can be erected independent of the tanks and walls, in combination with the horizontal 16-in. pipes, will accommodate rates of sludge flow corresponding to sedimentation rates to and including 1 600 gal. per sq. ft., without exceeding the allowable friction loss. Should future requirements so demand, the 14-in. pipes can be removed and a larger size substituted.

The waste sludge has been referred to only casually, for the reason that it is in sufficient quantity to influence the conditions of flow through the plant. For example, if the daily accumulation of sludge in the plant is at the rate of 15 000 gal. of 98.5% moisture material per million gallons of sewage treated, the total daily quantity for the 1930 period will be about 1 275 000 gal. and for the 1950 period about 1 920 000 gal. It can be readily seen that this comparatively small quantity, when distributed over the entire plant, would have no appreciable effect on any calculations pertaining to the plant hydraulics.

Air-Distribution System.

The compressor plant for furnishing air will consist of four, 30 000 cu. ft. per min., Ingersoll-Rand turbo blowers direct connected to Allis Chalmers steam turbines. There will be three active units and one spare.

No attempt will be made by the writer to give a detailed description of the proposed compressor and power plant. Only a few references will be made to the arrangement, character, and capacity of the machinery. Each blower will take its supply of air from the outside atmosphere through screened louvers along the east side of the power house and just below the roof.

The air will pass downward to the blowers through 36-in., cast-iron, inlet pipes equipped with Venturi meters and spray washers for measuring and washing the volume of free air to be compressed. After being compressed, the air will be discharged through 30-in., cast-iron, outlet pipes and enter the main air-header leading to the plant. The capacity of each unit, should be interpreted as meaning 30 000 cu. ft. of free air per minute compressed to 10 lb. per sq. in.

The air requirements for the 1930 plant are based on supplying air to the aeration tanks at the rate of 1½ cu. ft. of air per gallon of sewage treated. The conversion of this figure to a single diffuser-plate basis, assuming that sewage is being treated at the rate of 15 000 000 gal. per acre per day, with a diffuser ratio of 1 to 4, results in a figure which indicates that each diffuser plate will pass air at the rate of 1.48 cu. ft. per min.

Each aeration unit will actually contain 2 514 diffuser plates, and if each plate is supplied with air at the rate mentioned, the total air required per minute per aeration unit will be about 3 820 cu. ft. and, for the twenty-four units, about 90 680 cu. ft.

Air will be supplied for agitation to the diffuser plates in all the aerated channels, at the approximate rate of 1 cu. ft. of air per diffuser plate per minute. The total number of plates in the channels is 11 520 and will require about 11 520 cu. ft. of air per minute. The total quantity of air required for the aeration tanks and channels will be at the approximate rate of 103 200 cu. ft. per min. It will be noted that this quantity exceeds the combined rated capacity of the three active blowers which is 90 000 cu. ft. per min. at a pressure of 10 lb.

The secondary rating of the blowers, which is approximately 35 000 cu. ft. of air per minute at a pressure of 8 lb., indicates an available combined capacity of 105 000 cu. ft. per min. for the three units. This capacity is more than ample to satisfy the air requirements for the plant, and it is questionable whether the pressure losses in the air-distribution system as a whole will ever exceed 8 lb. per sq. in.

Experience in operating the plant at the testing station has shown conclusively that when foreign substances, such as dirt and oil, are eliminated from the air supply, there is little danger to be anticipated from the clogging of diffuser plates and the resulting increase in pressure.

The equipment which has been selected and purchased for compressing and washing the air, was designed and constructed under specifications which required a 100% performance relative to the quality of air delivered. The importance of a constant clean air supply is vital to the operation and maintenance of an activated sludge plant and should not be under-estimated.

The problem of designing an adequate and practical piping system for the distribution of air was given a great deal of study and consideration and was finally developed from the following basic conclusions.

First.—That the drop in pressure due to frictional losses in the pipes should not exceed ½ lb., based on the estimated requirements for the 1950 plant. This allowance does not include the fixed loss through the check-valve and gate-valve on each blower outlet pipe and the loss through the diffuser plates.

Second.—That accurate and convenient facilities should be provided for measuring the volume of air supplied to each aeration unit and to the mixed liquor, feed, and return-sludge channels.

Third.—That the pressure drop in the aeration units should be based on the quantity of air required to treat sewage at the rate of 20 000 000 gal. per acre per day, allowing 1½ cu. ft. of air per gallon of sewage, or 1.98 cu. ft. of air per diffuser plate per minute.

General Arrangement of Air-Piping.—One of the first steps in the design was to give separate consideration to the depths of liquor in the aeration units and in the channels. The depth of liquor in the aeration units, as noted previously, is 15 ft.; that in the feed and mixed liquor channels is 10 ft.; and that in the return-sludge channels is about 5½ ft. maximum.

The largest proportion of the total quantity of air is used in the aeration units. It is here, also, that the maximum pressure is required, owing to the depth of the liquor.

It was decided, therefore, after having compared the cost of providing and operating separate low-pressure blowers for supplying air to the channels with the cost of supplying air at an excessive pressure from the large units, that better economy could be obtained through the use of a system of sub-headers carrying pressure suitable to the depth of liquor, the supply of air being taken from the main air-headers and the reduction in pressure obtained through resistance in pressure-reducing valves.

The two sub-headers which supply the feed and mixed liquor channels with air, are connected to the two main air-headers at points about opposite the center of the middle units of the 1950 plant, the connection pipes, which are 12 in. in diameter, being equipped with pressure-reducing valves and air meters.

The sub-header supplying air to the return sludge channels and the mixing channel is connected to the main air-header at the western end of the plant, in the gate-house. This connection which is 8 in. in diameter, is also equipped with a pressure-reducing valve and an air meter.

Each aeration unit will take its supply of air directly from the main air-header, the connection being made at the top of the header in order to avoid carrying condensate into the piping of the aeration unit.

The connecting pipes between the main air-headers and the piping in the aeration units are 12 in. in diameter and each pipe is equipped with a gate-valve and an air meter.

Determining the Air-Pipe Sizes.—Research work carried on in connection with securing data and information pertinent to the allowance of adequate pipe capacity for the air, led to the adoption of the "Thorkelson" formula. This formula may be expressed as follows:

$$P = \frac{L\,V^2}{25\,000\,B}$$

in which

P = loss of pressure, in ounces per square inch.
L = length of pipe, in feet.
V = velocity of air, in feet per second.
B = diameter of pipe, in inches.
25 000 = constant.

Twelve diameters of pipe are allowed for bends of 90 degrees.

The air compression in the blowers will occur under adiabatic conditions, and the compression factors used for determining compressed volume, velocity, and the resulting pressure drop, were based on this condition.

It is quite likely that some of the heat of compression contained in the air will be lost in the air mains through radiation, resulting in loss of volume, less velocity, and less friction. Possibly, however, this loss will be made up by the heat resulting from the friction of the air against the walls of the pipe, and, consequently, the compression factors used were not corrected for heat losses resulting from radiation.

The allowable pressure drop of 8 oz., which was used as a basis in proportioning the pipe sizes, was determined from cost comparisons (Table 2) prepared to indicate the probable relation between the cost of compressing air and that of enlarging the pipe sizes to reduce friction losses.

TABLE 2.—Relative Costs, Based on the Air Requirements for the 1950 Plant.

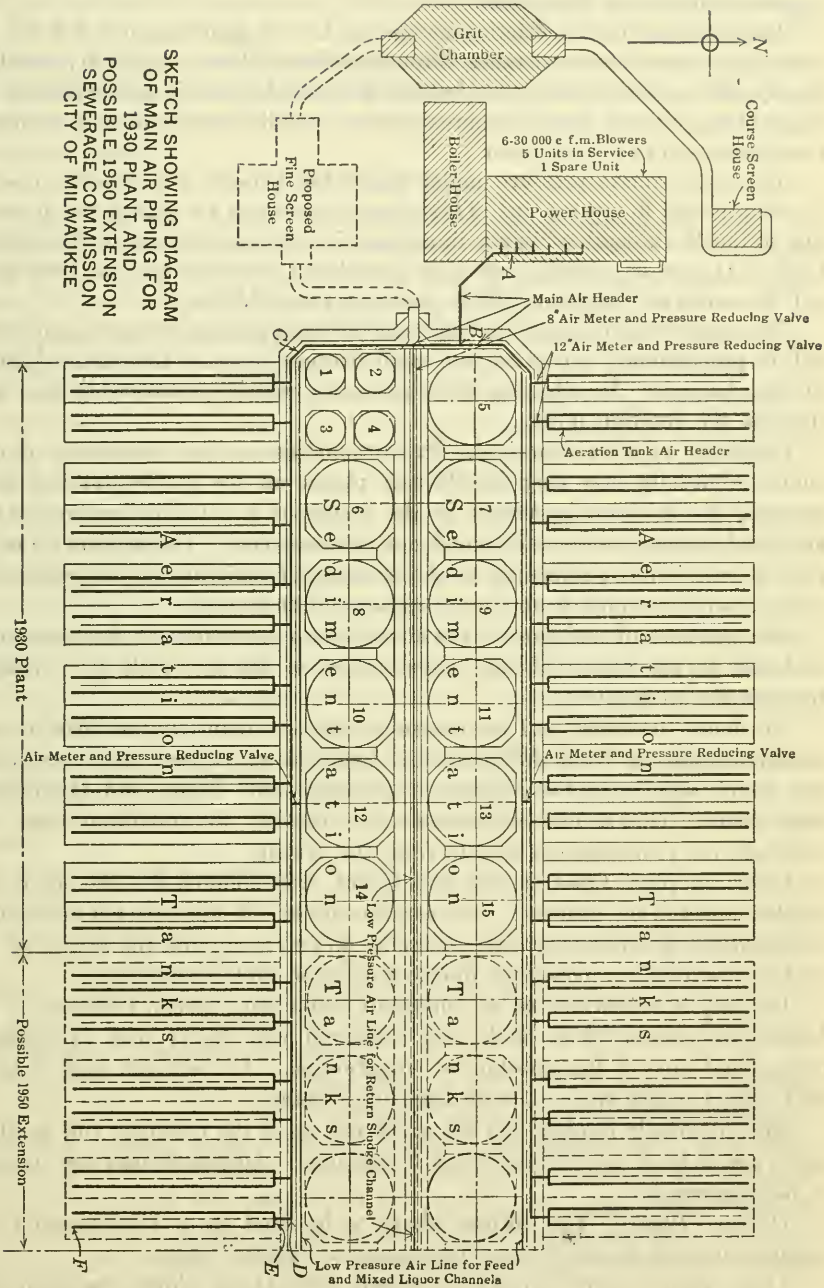
Pressure.	Annual Cost of Compressing 150 000 Cu. Ft. of Free Air per Minute.	Cost of Air Mains.		Annual Charges.
	Percentage of cost.	Percentage of cost.	Interest percentage on cost at 6%.	Percentage of cost of compressing air plus interest on pipe installation.
(1)	(2)	(3)	(4)	(5)
7 lb. 4 oz..	90+	174—	174—	93—
7 " 5 " ..	91+	168+	168—	93+
7 " 6 " ..	91+	161+	161+	94+
7 " 7 " ..	92+	155+	155+	95—
7 " 8 " ..	93+	149+	149+	95+
7 " 9 " ..	94+	143—	143—	96—
7 " 10 " ..	95—	137—	137—	96+
7 " 11 " ..	96—	131—	131—	97+
7 " 12 " ..	97—	125+	125—	98—
7 " 13 " ..	97+	118+	118+	98+
7 " 14 " ..	98—	112+	112+	99—
7 " 15 " ..	99+	107+	107+	99+
8 " 00 " ..	100	100	100	100

The assumption has been made that increasing the size of the air-pipes will increase the cost of the installation at a rate theoretically proportional to each 1 oz. increment of reduced pressure drop. This assumption, however, is not correct, because of the fact that, in enlarging the air-pipes to reduce friction losses, only those sizes which show comparatively large losses would be increased substantially, and those which show lesser comparative losses would be increased in lesser proportion.

Although the comparative values, shown in Column (5) of Table 2, would not be the same as those which would result from actual cost analyses of various air-pipe combinations, corresponding to the pressure differences shown in Column (1), the general tendency of the annual charges to decrease as the friction losses are decreased, would appear to hold strictly true.

In consideration of the foregoing indications relative to the economical necessity for maintaining friction losses in the air mains at a practical minimum, a careful study of all the conditions entering into and affecting the actual installation of an air-pipe system was made, with the result that the combination of sizes finally adopted appeared to suit best the conditions.

The friction losses were calculated along the line, *A-B-C-D-E,* on Fig. 3, which is a diagram of the main air-piping for the 1930 plant and possible 1950 extension. Point *A* is in the power house; Point *B* at the junction of the 66-in. and 60-in. pipes in the gallery, just north of the center of the plant; Point *C* at the southwest corner of the south gallery; Point *D* at the extreme end of main air-header in the south gallery; and Point *E* at the top



SKETCH SHOWING DIAGRAM OF MAIN AIR PIPING FOR 1930 PLANT AND POSSIBLE 1950 EXTENSION SEWERAGE COMMISSION CITY OF MILWAUKEE

FIG. 3.

surface of the most remote diffuser plate in the far end of the most easterly aeration tank in the 1950 plant.

The total loss due to friction along this line is approximately 0.5 lb.; the fixed loss allowed for resistance through diffuser plates is 0.75 lb., which is simply safe, and the fixed losses occurring at the blowers is approximately 0.3 lb., making a total loss of approximately 1.55 lb., based on the estimated requirements for the 1950 plant.

The approximate pressure under which the blowers will possibly operate in 1950 is 8.06 lb. per sq. in. This figure is obtained by adding the pressure due to the 15-ft. depth of liquor in an aeration unit to the sum of the friction losses. It can be readily seen that the blower pressure for the 1930 plant will be somewhat less than 8.06 lb., possibly about 7.75 lb.

The pressure of the air supplied to the channel piping, as stated previously, will be proportioned, except for the small friction losses, to the depth of liquor in the channels. In all cases these pressures will be considerably less than those in the aeration units.

Character of Pipe Required.—Precautions against the formation of rust which eventually may clog the diffuser plates, on the inside walls of pipes carrying air, is quite important in the design of an air-pipe system for the activated sludge process and should not be overlooked. The tendency for the pipe to rust is due principally to the presence of moisture in the compressed air, a condition which it appears is impossible to prevent.

The presence of moisture in the air is due to conditions of the atmosphere and also to the action of the water sprays on the air while it is passing through the air-washers.

No doubt, moisture will be present in the air mains in the form of condensate, resulting from differences in temperature between the compressed air, which will leave the blowers at probably 140° Fahr., and the outside atmosphere. This condition indicates the necessity for providing traps and blow-offs for removing condensate from the system.

Cast-iron pipe, Class *A* bell and spigot, was adopted for the main air-headers and for the headers in the aeration units. It was selected on account of its lasting qualities, rigidity, resistance to corrosion, and the ability of the lead joints to allow movement due to expansion and contraction.

Rigidity is referred to as an important factor with special reference to the larger sizes—from 36 to 66 in.—as compared with equal sizes of made-up commercial pipe of less substantial construction. All cast-iron pipe is to be well coated inside and out, with asphaltum paint.

All the sub-air headers and the small piping in the channels and aeration units are to be of galvanized wrought-iron pipe. All the fittings are likewise to be galvanized.

Diffuser Plates.—The diffuser plates to be used are a kiln-burned silica product and are known by the trade name of "filtros" plates.

These plates, which are 12 in. square and 1½ in. thick, are hard and porous and will not disintegrate or show signs of deterioration when they are immersed in sewage and subjected to the chemical actions taking place therein.

The specifications under which the filtros plates are being manufactured for the Sewerage Commission of Milwaukee provide that each plate, when dry, shall pass air at the rate of from 8.9 to 12.9 cu. ft. per min. under a 2-in. water pressure. The plates are to be placed in precast concrete containers. The setting of the containers and making the air-pipe connections thereto will not be done until the construction of the aeration units and channels is practically completed.

Notes and Data.

A great deal may be said in connection with the details of the design for any large structure, especially one subjected to the influence of conditions which, by virtue of the environment of a fixed location, involve considerations relating to the study and application of hydro-static forces.

The conditions influencing and controlling the design of the structure for the disposal plant at Milwaukee do not differ, to any great extent, from those which have been encountered and studied elsewhere, and, although certain features of the design are based on data and analyses of conditions, probably not heretofore generally used, the design as a whole possesses no unusual features.

The shape and size of the tract for the sewage disposal works were determined in conjunction with the development of plans for the proposed harbor improvements. The decision arrived at relative to the arrangement of the disposal works as a whole was that the necessary structures for the cage screens, rack screens, fine screens, grit-chambers, blowers, generators, boilers, presses, and dryers, should be located on the fast land of the tract and that the aeration units and sedimentation tanks should be constructed on a site to be prepared in Lake Michigan adjacent to the fast land.

In accordance with this decision, a large coffer-dam was designed and constructed, and the enclosed area which is approximately 700 ft. by 900 ft., after having been dredged hydraulically to about Elevation —12.50, was dewatered.

The fact that all the structures would have to be placed on pile foundations was recognized from the beginning, and a series of tests were undertaken to determine the allowable bearing for the piles. A complete description of the pile tests, although containing much interesting data, is too lengthy to be presented herein. The final results, however, indicated that a bearing of 16 tons per pile would be sufficiently safe to use in connection with the design, and that figure therefore was adopted.

Conditions of Loading on Piles.—The condition of loading on which the spacing of piles was determined, took into account the total dead weight of the tanks and channels, and also the weight of the sewage contained in them when filled. The piles under the sedimentation tank bottoms are spaced 5 ft., center to center, both ways, and those under the aeration unit bottoms were spaced 5 ft. 6 in. in one direction and 4 ft. 7 in. in the other. In each case, the loading requires 1 pile for approximately each 25 sq. ft. of area, except under the walls where closer spacing is needed.

When the construction is completed, and the plant is placed in service, the ground-water level which, during construction, is being maintained lower

than the bottom of the site, by continuous pumping, will be allowed to seek its own level, which will probably be the same as the prevailing stage of water in Lake Michigan.

If the level of the water in Lake Michigan is Elevation 0.00, the uplifting force acting on the bottoms of the sedimentation tanks will be that due to a hydrostatic head of 13 ft., or about 812 lb. per sq. ft., and that acting on the bottoms of the aeration units will be about 740 lb. per sq. ft., or that corresponding to a hydrostatic head of 11.83 ft.

In considering the uplifting force in connection with the design, full value was given to the intensity of this force, no allowance whatever being made for resistance due to percolation through the soil, or for the probable inability of the pressure to exert itself over the entire bottom of the tanks, which will be poured in place directly on the sandy bottom of the tract.

This uplifting force, of course, will be more than balanced by the weight of the tanks and channels which will be filled with sewage when the tanks are in service, and partly balanced by the weight of the structures alone when empty. It is the latter condition which must be met to insure the stability of the plant against conditions likely to be met in operation, which would require the emptying of the units.

Two methods of satisfying this condition were carefully considered: One to provide sufficient weight in the structure itself to balance the uplift, and the other, to provide a sufficiently rigid anchorage or bond between the pile-heads and the concrete and utilize the holding down power of the piles.

For reasons of economy, the latter method appeared to be the more favorable, and a series of elaborate tests were conducted to determine, if possible, the best and most adaptable type of anchorage.

The tests, which were conducted by R. R. Lundahl, Assoc. M. Am. Soc. C. E., Division Engineer, indicated that a plain pile-head, stripped of the bark and embedded 10 in. in the concrete, would develop strength in bond, with an ample safety factor, sufficient to equal the holding down power of the pile, which was fixed, with safety, at 50% of the bearing value, or about 8 tons. The maximum uplift on the piles as spaced will not greatly exceed 6 tons per pile.

In view of the results of these tests, the designs provided for each pile-head to be embedded 10 in. in the concrete bottom, and the weight of the structures was based on the requirements for strength alone.

Design of Bottoms.—Flat slabs, reinforced in two directions, top and bottom, were used for the sedimentation tank and aeration unit bottoms. The loads used were those which have already been mentioned in connection with the bearing and uplift on the piles.

A section of slab, the length of each side being equal to twice the distance between pile centers, was used as the unit area on which to calculate the thickness of the concrete and the percentage of steel.

The selection of the dimensions for the slab, which dimensions were considered sufficiently substantial to warrant their use, was governed by considerations relative to the possibility of unequal settlement of the piles and the resulting tendency to set up uncertain conditions of strain in the bottoms,

which, if not adequately guarded against, might be conducive to ultimate rupture.

The steel reinforcement in the top of the slab is proportioned to the moment resulting from the hydrostatic uplift, and the negative moment over the supporting piles is due to the force of the downward loads. The steel in the bottom of the slab is proportioned to the downward loads acting independent of the uplift.

Design of Walls.—Main walls of the cantilever type, reinforced on both sides and supplied with 0.003% of temperature steel, were designed for the aeration units, sedimentation tanks, and channels.

Walls subject to the same water pressure on both sides were proportioned and reinforced to withstand the total load from either side. Walls subject to a combined earth and water load on one side and a water load on the other side, were treated in a similar manner.

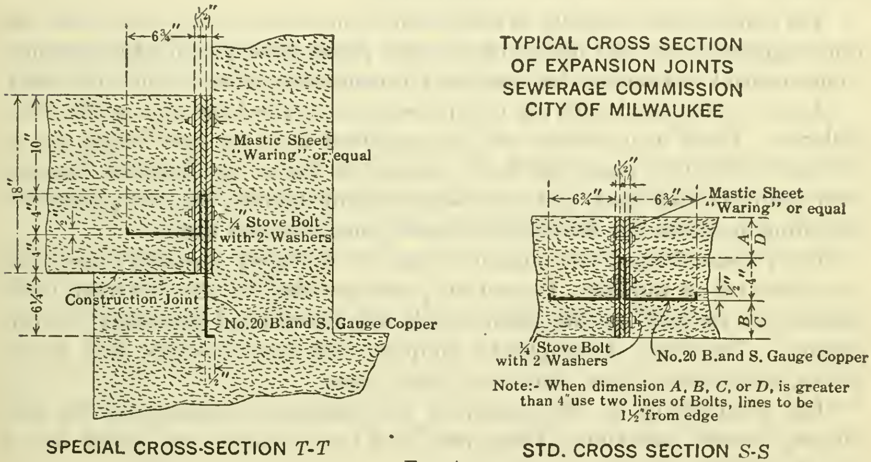


Fig. 4.

The loading referred to as combined earth and water is that due to back-fill in contact with outside walls and to the hydrostatic condition of the back-fill which is assumed to be completely saturated below zero elevation. The horizontal unit pressure exerted by the saturated back-fill is assumed to be about 100 lb. per sq. ft. for each foot of depth.

The tension allowed in the steel throughout the design was 16 000 lb. per sq. in., and the maximum compression allowed in the concrete was 650 lb. per sq. in.

Expansion Joints.—Expansion joints of the general type shown as Sections *S-S* and *T-T* in Fig. 4, were incorporated in the design. Where used, these joints completely separate the adjacent parts of the structure.

Each entire section of the plant between the expansion joints is securely tied together with reinforcing rods and, from a structural standpoint, is a self-contained unit. The copper sheet is to be stitch-riveted and soldered at joints, corners, and intersections, in order to secure water-tightness.

Galleries.—The operating galleries will be constructed of brick, with reinforced concrete and composition roofing and steel roof beams.

The exterior treatment will harmonize with the general architectural scheme adopted for all the buildings which will have been constructed when the entire plant is completed.

The design contemplates the use of steel doors and windows throughout. Subway grating, 1 in. deep, of "Irving" Type G, in connection with concrete slabs, will be provided for walk-ways and covers throughout.

General.

The "thickeners", or concentrators, with which all of the sedimentation tanks are to be equipped, will be supported from steel trusses spanning the tanks. The reduction gearing, motors, etc., for driving the apparatus, will be mounted on the top chords of the trusses and will be protected from the elements by housings of hy-rib construction.

The starting and stopping switches will be mounted on the walls inside the center gallery and near the sludge outlet pipes, thus placing the complete sludge-control mechanism for each unit conveniently close to the unit itself.

A 4-in. water main carrying city pressure is provided for each of the three galleries. These mains which will be suspended from the roof beams, are to be fitted with drop pipes and hose connections 2½ in. in diameter, opposite each sedimentation tank and each aeration-tank battery, for the purpose of providing facilities for flushing the tanks, channels, and drains.

The present filtros-plate containers and the container separators are being manufactured at the rate of about 60 pieces per day, by the Sewerage Commission, in its own casting plant which was constructed especially for this purpose. The plant is completely equipped with the necessary steel forms, cranes, tram-cars, mixing plant, and steam room.

The manufacture of the containers and separators, particularly the containers, is work requiring extreme care, and the product being turned out of the plant is first-class in every respect.

Conclusion.

The work has been directed and developed under the direction of T. Chalkley Hatton, M. Am. Soc. C. E., Chief Engineer of the Sewerage Commission, and for several years past Harrison P. Eddy, M. Am. Soc. C. E., has been employed by the Commission in the capacity of Consulting Engineer.

Those of the Sewerage Commission staff, beside the writer, who have been associated intimately with the development of the process from its inception, and also with the more recent work of preparing final designs, are James L. Ferebee, M. Am. Soc. C. E., Principal Assistant Engineer; William R. Copeland, Affiliate, Am. Soc. C. E., Chief Chemist; A. Lawrie Kurtz, Assoc. M. Am. Soc. C. E., Division Engineer and Designer; Henry M. Reisig, Assistant Chief Chemist; Anthony J. Magerl, Architectural Engineer; H. Erskine Nicol, Senior Engineer; and M. Bert Langeler, Structural Engineer and Designer.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

RAINFALL AND RUN-OFF STUDIES

Discussion*

BY MESSRS. H. V. HINCKLEY, WALTER E. JESSUP, E. W. CLARKE, AND W. W. HORNER.

H. V. HINCKLEY,† M. AM. SOC. C. E. (by letter).‡—The Engineering Profession is certainly indebted to the author for making public the results of his investigations. The writer would not attempt to estimate the loss of capital invested in hydraulic works, during the past thirty or forty years, from lack of such information.

Time was when, in the absence of more complete information, the evaporation tests which had been made by water supply engineers along the Eastern seaboard—and which were widely published—were accepted as probably applicable over the United States in general. This mistake, coupled with a lack of appreciation of the distinctive differences between rainfall and run-off in different sections of the country, has been partly responsible for great losses.

The conditions prevailing in New England and the seaboard States, are quite dissimilar from those which prevail on the Great Plains. Even the casual observer, who travels, knows that in the Eastern States the streams flow the year around, while, in parts of the West, the streams are dry fifty-one weeks of the year and, human-like, make up for lost time by getting soaked and going beyond customary limits during a part of the remaining week.

The writer has previously referred§ to the comparative fluctuations of the Connecticut and Kansas Rivers. On the Great Plains, extremes prevail. Drainage areas, reservoir capacities, and spillway capacities must be maximum, while at times results as to water supply will be minimum. For example, since 1900 there have been two years when the run-off in parts of

* Discussion of the paper by C. E. Grunsky, M. Am. Soc. C. E., continued from December, 1921, *Proceedings*.

† With V. Y. Long & Co., Oklahoma, Okla.

‡ Received by the Secretary, December 6th, 1921.

§ *Transactions*, Am. Soc. C. E., Vol. LVIII (1907), p. 341.

Oklahoma, for sixteen months (including four months of the contiguous years, in each case), has been less than 4 in., while the evaporation for the same period has been about 10 feet. The writer discovered, in the early Nineties, that an average annual evaporation of 3 ft., or a maximum evaporation of 6 in. per month, did not apply to the case of hot winds on the Plains where evaporation was as high as 2 in. per day, for 15 or 20 days at a time.

The author's formula for annual run-off, in which P is less than 50 in., has always checked the writer's computations (based on actual measurements at neighboring points similarly situated), to within a small fraction of 1%, and those cases include the two extremely dry years previously mentioned. The writer, therefore, considers Mr. Grunsky's simple and easily remembered run-off formula one of the best tools in his engineering collection, and believes that it entitles the author to at least a passing compliment.

WALTER E. JESSUP,* Assoc. M. Am. Soc. C. E. (by letter).†—The author has collected and evolved formulas expressing relations between rainfall and run-off, which can be made to be very useful. It is desired, however, in connection with the examples presented by Mr. Grunsky of applications of his Equation (25), namely, $D_m = 413\ a\ M\ I$ sec-ft., giving maximum stream flow from the intensity of a rainfall on a large drainage area, to point out that this formula has its limitations.

The author has given, as examples, the drainage areas of the American River above Folsom and of the Sacramento River above Red Bluff. As stated, the greater part of the yearly precipitation on the Pacific Slope occurs during the winter months. The average elevation of the 1 900 sq. miles of the water-shed of the American River, is nearly 5 000 ft. above sea level. Therefore, a large part of the precipitation will fall as snow and will not run off at once. The average elevation of the 9 300 sq. miles of the water-shed of the Sacramento River is about 4 000 ft. above sea level, and a large part of the precipitation takes the form of snow for similar reasons. The floods on both these rivers occur for the most part in the spring of the year as a result of melting snows.

Assuming that the maximum rainfall of 8 in. in 24 hours should fall in the form of rain, on the water-shed of the American River in the spring, there will be added to the run-off from such a rain, the tremendous run-off from the melting of the accumulated winter snows, the result being a value far beyond the expectation of the formula. On the other hand, should this same precipitation occur during the winter, it will be retained largely on the watershed in the form of snow, and only a small proportion of the run-off, as computed from the formula, will result. Such unreasonable results will also obtain from a maximum rainfall of 6 in. in 2 days on the water-shed of the Sacramento River.

It would seem, therefore, that the application of the formula has been carried beyond a reasonable limit, and that it will not apply to such large water-sheds where the conditions affecting precipitation are so variable.

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† Received by the Secretary, December 7th, 1921.

E. W. Clarke,* M. Am. Soc. C. E. (by letter).†—The writer is interested in Mr. Grunsky's suggested method of expanding short-period rainfall records, and although it is understood that special reference is made to California conditions, it may be worth while to compare the theoretical results obtained by the expansion with the rainfall at some long-term stations in New England, using still longer records at other stations as a base.

X. H. Goodnough, M. Am. Soc. C. E., Chief Engineer of the Massachusetts State Board of Health, has collected a large number of rainfall records in New England,‡ some of which are as follows:

New Bedford, Mass	1814–1920
Boston, Mass	1818–1920
Providence, R. I	1832–1920
Lowell, Mass	1826–1920
Amherst, Mass	1836–1920
Waltham, Mass	1825–1920
Springfield, Mass	1846–1920
Concord, N. H	1853–1920

Using as the base time, the 50 years, 1871 to 1920, inclusive, and as the base stations, New Bedford and Boston, the rainfall was calculated to the limit of each of the other stations from one or the other of the base stations and sometimes from both; also, in a few cases, by using one of the sub-stations as a base, and the results of these calculations and the actual recorded rainfall were plotted.

The plotting of the annual rainfall showed that, in general, a wet or dry year at the base was also a wet or dry year at the sub-station, but the theoretical and actual quantities are often far from agreement. In cases where the theoretical rainfall was calculated from both bases, there is also generally a lack of agreement between these figures.

The mass curves showed that there may be practical agreement for a number of years, but this agreement never follows throughout the entire period and it happened, in most cases, that the difference is on the wrong side, that is, less rain fell than the calculations indicated as probable.

The maximum distance between stations is about 95 miles. At the various stations, rainfall conditions differ, but the writer does not consider them so dissimilar as to make it unfair to the theory to include them in the test. If the application of the theory is confined to much smaller areas than this, its value is nullified. So far as these few cases indicate, distance within these limits does not seem to be a factor, since the variation between the theoretical and actual at Amherst, calculated from Boston 75 miles away, is no greater than at Waltham, 12 miles distant from Boston.

This test of the theory apparently indicates that, as far as New England records are concerned, reliance cannot be placed on this method of expanding short-term records to give even approximate estimates of the precipitation for

* Dist. Plant Engr., U. S. Shipping Board, Baltimore, Md.

† Received by the Secretary, December 15th, 1921.

‡ *Journal*, New England Water Works Assoc., September, 1915, and September, 1921.

the years not covered by the record. In view of the general discordance of the theoretical and actual rainfall lines, not much reliance can be placed on the calculated maxima and minima; on the contrary, at one station the maximum and at four stations the minimum estimated, was exceeded by the actual rainfall.

W. W. HORNER,* M. AM. SOC. C. E. (by letter)†.—The writer feels that Mr. Grunsky's paper, as supplementing his earlier paper on the same subject,‡ is of the greatest interest to the Engineering Profession, particularly in keeping before engineers the lack of information available on certain phases of this subject. With the adoption of the rational method of determining run-off, a great step was made in advance in this particular science. For its satisfactory application there are two fields in which study is still required, the first relating to intensities and duration of rain, and the second to the rates of run-off.

With the increasing number of automatic rainfall gauges installed, knowledge of the variations of rainfall intensities, with respect to the duration of the rain, is rapidly approaching a satisfactory condition. The writer has made a study of a number of records for various localities, and although Mr. Grunsky's parabolic formula of variation does not appear to conform closely to general data, the writer believes that its use will be valuable in a preliminary way in districts where detailed studies are not available. He agrees with the author that it should never be used where sufficient observed data are available to permit of a satisfactory rainfall curve for the particular locality, or where such curves are available in the same general district and under the same meteorological conditions.

Another phase of the rainfall studies on which little information is available is the intensity and area of relationship, that is, a determination of the area over which single-station maximum records are applicable, or the extent to which they should be reduced in applying them to large areas. In a number of cities, a sufficient number of automatic rainfall gauges are now located to permit of a study of this kind. It is being undertaken in the City of St. Louis, Mo., in the analysis of ten-year records from five gauges, and it is hoped that, in another year, something of value may be available from this source.

In the matter of percentages of run-off, or of rates of run-off for particular intensities, the writer feels that little progress has been made. Engineers are still dealing almost entirely with arbitrary values, or, in a few instances, with values based on personal experiences. Published gaugings on existing sewer districts are few, and many of the records are faulty. Even where the records are unquestionable, the results for different storms vary so widely that engineers have not yet been able to make them conform to a definite theory. The writer has no doubt that as such records multiply, accompanied with all the information which may be of interest as affecting run-off, some definite values will be developed.

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† Received by the Secretary, December 23d, 1921.

‡ "Rain and Run-Off near San Francisco, California", *Transactions*, Am. Soc. C. E., Vol. LXI (1908), p. 496.

The studies of the first three years of gaugings in St. Louis were rather discouraging, and the matter was laid aside for the accumulation of further data. With records for ten years now available, it is again hoped that some law of variation in run-off will become discernible. These gaugings, like most of those heretofore recorded, deal with the run-off of mixed urban areas of from 20 to 500 acres in extent. The writer has long felt that the analysis of these records would be much simplified by a study of the run-off of small plots of uniform character. In an effort to secure such data, the run-off from single blocks is being studied in St. Louis, and it is also proposed, in the near future, to make a study of the run-off on large roofs. To complete this series, observations will be made of the run-off from small plots of natural soil.

The writer has been interested in the results of the study of this character made by the Miami Conservancy District and published in Part 8 of its Technical Reports. These results give definite information of the effect of varying intensities of rainfall on run-off from natural soils in the vicinity of Dayton, Ohio. It is surprising to note the capacity of these soils for continued absorption of surface water and for passing this water through to the underlying gravels. The measurements show clearly that, for the shallow topsoils and glacial gravels of this part of the United States, the percentage of run-off will decrease with the decrease in intensity, or, in general, with the duration of the storm. It should be evident, however, that this variation is not applicable outside these particular soil conditions, and it is to be expected that, with the surface loams and plastic clays found generally south of the Ohio and Missouri Rivers, saturation may be expected in a comparatively short time, and that, in most instances, the percentage of run-off will increase with the duration of the rain.

The writer feels that this latter relation will also apply to most urban areas, and that some variable factor of run-off must be introduced into the application of the rational method, rather than values such as the a suggested by Mr. Grunsky,* which are constants for any particular density of population.

There is no doubt that engineers must take account in some way of the reduction of run-off due to water in storage on the surface, and to a minor extent in the conduits. Mr. Grunsky's factor of 0.645 is apparently a secondary run-off coefficient to allow for this effect. Ultimately, the propriety of any constant value for this purpose may be questionable. With the present knowledge of the subject, however, Mr. Grunsky must be commended for his effort to take this into account.

The writer feels that Mr. Grunsky's Table 6 is unfortunate, in that it shows values extending far beyond the range which the author claims for his formula. It would seem preferable to have introduced only the lower part of this table, dealing with times of from 1 to 20 days. The writer feels the more strongly on this point because he does not believe that the marked reduction of the values of a with an increase in time are justified for rains of

* *Proceedings*, Am. Soc. C. E., September, 1921, p. 233.

less than 1 day, and seriously questions whether, for these short times, the values of a should not increase somewhat as the time increases.

The writer's experience with the application of the rational method in the design of sewers in St. Louis has led him to the conclusion that the simple and direct use of the method involves less work than the solution of formulas of the type presented by Mr. Grunsky. It would seem unfortunate to have to make preliminary studies of the water-shed for the purpose of determining the time of flow, and of drainage areas which would correspond to fractions of this time, when in the ordinary use of the rational method the solution in each section of the conduit provides all the data of this type required for the succeeding section. It appears that the use of Mr. Grunsky's formula will involve about twice the arithmetical work required by the simple application of the rational method.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

THE RELATION BETWEEN DEFLECTIONS AND STRESSES IN ARCH DAMS

Discussion*

By Messrs. William Cain, B. F. Jakobsen, and Charles P. Dunn.

William Cain,† M. Am. Soc. C. E. (by letter).‡—With regard to the Barren Jack and the Salmon Creek Dams, the author raises the interesting question as to whether they can be regarded as fixed at the base or simply supported there. The bending moment on the supposed vertical cantilever at the crown, 1 ft. thick, the weight of the cantilever being neglected, has not been computed for either dam. It has been computed for the Wooling Dam and, at the base, for full water load, the bending moment§ is: $M_w = 220\,900$ ft-lb., and for a fall of temperature of 20° Fahr., $M_t = 127\,700$ ft-lb.

The Wooling Dam is 33 ft. high, vertical on the reservoir side, 2.2 ft. thick at the crest, and 4.4 ft. thick at the base, and will be supposed not to be reinforced. By the usual formula, $M = S\,\dfrac{I}{c}$, the unit tension on the up-stream side of the cantilever at the base, due to M_w, is 475 lb. per sq. in., and that due to $M_w + M_t$, combined, is 708 lb. per sq. in. The weight of the dam, 16 335 lb., acts vertically; the line of action cutting the base 0.49 ft. up stream from the center, gives a compression of 43 lb. per sq. in. at the up-stream side. Therefore, the total unit stress, due to the bending moments and the weight of the dam, are: Water load and weight of dam, 432 lb. per sq. in.; and water load, fall of temperature of 20° Fahr., and weight of dam, 665 lb. per sq. in.

For either case, plain concrete would crack and the dam could only be regarded as supported at the base with no resisting moment there. At first, when the water is sufficiently low and the temperature is near the mean, the bending moments could be resisted by the base and the cantilever would be

* Discussion on the paper by F. A. Noetzli, Assoc. M. Am. Soc. C. E., continued from December, 1921, *Proceedings*.

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‡ Received by the Secretary, November 26th, 1921.

§ *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 2068, Table 4, and p. 2075, Table 6.

fixed at the base, with a vertical generator. Should the water gradually rise, or the temperature gradually fall, a stage would be reached at which the tension on the up-stream side of the cantilever would exceed the limit for concrete in tension (100 to 200 lb. per sq. in.), and the concrete would crack. The cracking would continue as the water rose to the crest and the temperature fell to 20° Fahr., and the dam would change from the condition of fixed at the base, to that of simply supported at the base, with no bending moment there and with a generator inclined down stream for reasons to be given later. Since the dimensions of the Barren Jack Dam do not differ greatly from those of the Wooling Dam, the conditions at the base are practically the same, or the dam is simply supported at the base.

The solution of the Wooling Dam, not reinforced, regarded as simply supported at the base, with no bending moment there, was given by the writer,* using 7-place logarithms. In the course of the elimination, too few significant figures were left in certain cases to determine accurately the quantities, particularly the deflections at depths from 22 to 29.3 ft. below the crest. On that account, the solution was repeated, using 8-place logarithms with more satisfactory results. The results are recorded in Table 1, in which,

u = radial deflection at the crown; down stream +, up stream —;
T = tangential stress in the horizontal arch; compression +, tension —;
M = moment in vertical cantilever, reckoned as positive when the bending tends to make the generators of the upper cylindrical surface concave to the axis.

TABLE 1.—Wooling Dam, Simply Supported at the Base.

d, depth, in feet, below crest.	Water Load, Reservoir Full:			Rise of Temperature of 20° Fahr., Reservoir Empty:		
	u, in inches.	T, in pounds per foot height.	M, in foot-pounds per foot width.	u, in inches.	T, in pounds per foot height.	M, in foot-pounds per foot width.
0	+ 0.362	+ 94 600	— 300	— 0.270	— 23 170	0
3.6	+ 0.342	+ 99 100	— 4 300	— 0.245	— 18 680	+ 1 150
7.3	+ 0.319	+ 101 959	— 15 300	— 0.220	— 12 640	+ 4 100
11.0	+ 0.293	+ 101 900	— 30 300	— 0.194	— 4 850	+ 8 280
14.6	+ 0.261	+ 98 300	— 46 200	— 0.166	+ 5 160	+ 12 940
18.3	+ 0.221	+ 89 700	— 59 400	— 0.136	+ 17 490	+ 17 080
22.0	+ 0.171	+ 74 400	— 66 500	— 0.104	+ 32 710	+ 19 330
25.6	+ 0.121	+ 56 048	— 62 100	— 0.070	+ 50 260	+ 18 500
29.3	+ 0.062	+ 30 566	— 41 900	— 0.035	+ 70 690	+ 12 600
33.0	0.000	0	0	0.000	+ 92 880	0

The graphs of the quantities u, T, and M, are given in Figs. 6 and 7, the first referring to the water load, the second to the rise in temperature. The vertical line represents the vertical face of the dam with the up-stream side on the right. The scale of the M-curve in Fig. 7 is greater than that of the M-curve in Fig. 6.

The deflection curve for water load makes an angle with the vertical at the base, the tangent of which is $\frac{0.062}{3.7 \times 12} = 0.001396$, the angle being 4′ 48″.

* *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), pp. 87–91.

For the temperature curve, the corresponding angle is 2′ 43″. The influence of the weight of the cantilever has not been included in Table 1. Also, since $M = 0$ at the base, there can be no vertical pressures on the base due either to water pressure or temperature change. The inclinations of the deflection curves to the vertical at the base are evidently due to the difference in the arch thrusts, at and just above the base, corresponding to different deflections. Thus, at the base, $T = 0$, and there is no displacement; whereas at $d = 29.3$, the compression for water load, $T = 30\,566$ lb. The consequent shortening of the horizontal arch there gives a displacement down stream.

This is the full and complete explanation of the angles in question for the Wooling Dam, and the writer believes that it applies equally to the Barren Jack and Salmon Creek Dams. The case is one of shear (as in the case of torsion), in which each horizontal arch of infinitesimal height, slips over the one just below it.

This reasoning does not explain the "knees" in the deflection lines of the Salmon Creek Dam, since for a homogeneous dam, the deflections should con-

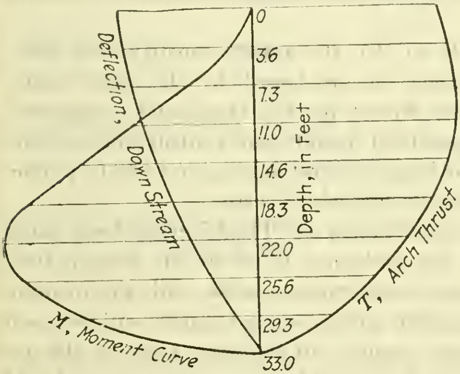

FIG. 6.

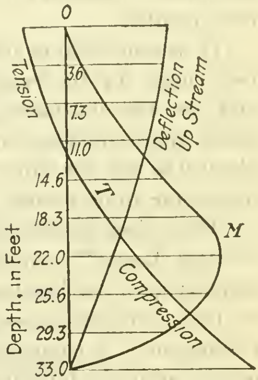

FIG. 7.

tinue to increase to the top (Figs. 6 and 7). The material was evidently not of uniform quality there, and it looks reasonable to suppose a weakening of the cantilever and a possible crack.

Attention may be called to the crossing of the deflection curves of May 25th and August 10th, 1909, of the Barren Jack Dam. Of course, the first curve should lie entirely to the right of the second, as the temperature is lower by 13° Fahr. The explanation appears either to be that the observations were inexact, or that the lower half of the dam did not respond as quickly as the upper part to the change in air temperature. The reservoir was full on both dates and the change in deflection at the crest was $0.58 - 0.52 = 0.06$ in., or 0.00462 in. per degree.

Compare this with the results for December 24th and December 26th, 1909, when, with the reservoir empty, there was a fall in temperature of 30° Fahr. and a deflection change of 0.052 in., or only 0.0017 in. per degree, less than half the preceding rate. It should have been greater than the preceding rate, for many of the arches were in tension and doubtless cracks were in evidence

both in the body of the dam and at the abutments, as there was no reinforcement. Evidently, in the two days, from December 24th to December 26th, the time was not sufficient for the dam to respond to the change in air temperature of 30° Fahr. There was a lag, and this should always be considered for cases of sudden changes of temperature.

In fact, there will always be a lag, even with slow changes in air temperature; and, during such periods, observations of the air thermometer should be recorded daily in order to make a reasonable estimate of dam temperature at a certain date; otherwise, the observations may prove worthless for computing stresses from deflections. For the Barren Jack Dam it is evident that the observations are not full and precise enough to give confidence in the results of computation of stresses for temperature changes only. For thick dams, the subject is further complicated in that the temperatures in the body of the dam vary considerably for the same date, although the analysis, leading to definite formulas, has been based on a constant temperature for the whole body of the dam at a given date. Then, again, in all cases, the uncertainty as to the modulus of elasticity of the concrete in the dam, suggests caution in stating final results.

In the derivation of Equations (1) to (9), the author substituted a parabolic arch for the circular one, replaced the arc length by the span length, and, for the abutment, used the crown thrust for the tangential component. Such approximations may lead to practical results for central angles from about 0 to 30°, for thin arches; but, for larger central angles, up to 180°, particularly for thick arches, the results may be greatly in error.

The writer has developed a nearly exact theory of "The Circular Arch under Normal Loads"*, which omits only the influence of shear on deformation, which paper, for brevity, will hereafter be referred to as **C**, with the formula or table referred to added. The notation given in that paper will be used throughout. A comparison of numerical results, for the same arch, by the use of the writer's formulas and tables and the author's computations, should prove instructive. To that end, consider the observations on the Salmon Creek Dam of October 8th, 1914, and October 27th, 1915. Since the temperatures are not given, they necessarily will have to be assumed to be the same. The deflection at Elevation 1 115, or 108 ft. above the base, on October 8th, 1914, was zero, and on October 27th, 1915, with the water reaching the crest, it was 0.82 in., which will be attributed entirely to the water load. Mr. Noetzli gives the following data: $E = 2\,500\,000 \times 144 = 360\,000\,000$ lb. per sq. ft.; $r = 282$ ft., $h = 76$ ft., and $t = 24$ ft. The central angle, consequently is $2\,\phi_1 = 86°\,10'$. Here, $\frac{t}{r} = 0.085$, and the deflection is $\eta = \frac{0.82}{12} = 0.0683$ ft. In the formulas, all dimensions are given in feet.

From **C** Table 1, for "fixed ends," $c = 1.74$ in the formula, $\eta = c\,\frac{p\,r^2}{E\,t}$. On solving this formula for $(p\,r)$ and substituting numerical values:

$$(p\,r) = \frac{\eta}{c}\,\frac{E\,t}{r} = 1\,150\,000 \text{ lb.}$$

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* *Proceedings*, Am. Soc. C. E., October, 1921, p. 285.

Therefore, $p = 4\,080$ lb. per sq. ft., and the water pressure on the extrados of the horizontal arch, 1 ft. in depth, is:

$$p' = p \frac{r}{r'} = 4\,080 \frac{282}{294} = 3\,913 \text{ lb. per sq.ft.}$$

The moment at the crown of the horizontal arch, at Elevation 1 115, is given by the formula,

$$M_0 = - a \frac{E\, t^3 *}{r\, h} \eta.$$

The coefficient, a, was computed, but the result, $a = 0.152$, was found to be the same as that obtained from C Table 3. Substituting numerical values,

$$M_0 = - 2\,435\,000 \text{ ft-lb.}$$

corresponding to compression at the extrados and tension at the intrados.

The thrust, P_0, at the crown is to be derived by aid of C Equation (12),

$$(p\, r - P_0) = \frac{- M_0}{r \left(1 - \dfrac{\sin \phi_1}{\phi_1}\right)} = \frac{2\,435\,000}{282 \times 0.0916} = 94\,400$$

Therefore,

$$P_o = (p\, r) - 94\,400 = 1\,055\,600 \text{ lb.}$$

By the well known formula:

$$s = \left(\frac{P}{t} \pm \frac{6\,M}{t^2}\right) \div 144,$$

the unit stresses, in pounds per square inch, at the crown, where $P = P_o$, $M = M_0$, are found to be:

At the extrados, $s = 468$ lb. per sq. in. (compression).
At the intrados, $s = 126$ lb. per sq. in. (compression).

Mr. Noetzli's figures are 461 and 91 lb. per sq. in., respectively.

At the abutment of this horizontal circular arch (of 1 ft. depth), the tangential component of the thrust, P_1, and the moment, M_1, must be computed from C Equation (4) and C Equation (3), or C Equation (13).

$$P_1 = (p\, r) - (p\, r - P_0) \cos \phi_1 = 1\,081\,000 \text{ lb.}$$
$$M_1 = M_0 + (p\, r - P_0)\, h = + 4\,739\,000 \text{ ft-lb.}$$

Therefore, by the formula for s, putting $P = P_1 = 1\,081\,000$, $M = M_1 = 4\,739\,000$ and $t = 24$, we find:

At the intrados, $s = 656$ lb. per sq. in. (compression)
At the extrados, $s = - 22$ lb. per sq. in. (tension)

The author's figures are, + 645 and — 89 lb. per sq. in., respectively.

At the crown, the center of pressure is $\dfrac{M_0}{P_0} = - 2.31$ ft. from the center of the crown joint, on the extrados side. The center of pressure then gradually approaches the center line of the arch ring, and crosses it where $M = 0$, or by

* The minus sign should have been given in the writer's paper previously mentioned. η is to be taken positive down stream, negative up stream.

C Equation (13), where $\cos \phi = \frac{\sin \phi_1}{\phi_1}$, or at $\phi = 24° 43'$. Below this point, the center of pressure recedes from the center line of the arch ring, gradually increasing its distance from it, until, at the abutment, the maximum departure from it, $\frac{M_1}{P_1} = + 4.39$ ft., is reached, on the intrados side.

The author gives, on page 277*, the dimensions for the highest arch of the Salmon Creek Dam. The deflection is 0.98 in. for a full reservoir. Following the previous method, we find,

$$(p\,r) = 287\,200 \text{ lb.}$$

$$p = 884 \text{ lb. per sq. ft.};\; p' = 850 \text{ lb. per sq. ft.}$$

$$M_0 = -\,18\,000 \text{ ft-lb.};\; P_0 = 287\,000 \text{ lb.}$$

At the extrados, $s = 353$ lb. per sq. in. (compression).
At the intrados, $s = 311$ lb. per sq. in. (compression).

The author does not attempt to estimate the part of the water load carried by this arch; therefore, no final figures are given.

These solutions of the writer are complete, since they include the effects of both bending moment and axial stress, so that nothing has to be added for axial stress due to water load.

When the observed deflection of an arched dam, at any point, is due partly to water load and partly to temperature change, the solution is more difficult. It will be found that the value of $(p\,r)$ can be determined accurately, but that the moments and stresses can be ascertained only approximately. The solution is based on the reasoning given by the writer in a previous discussion†, leading to the formula for deflection, D,

$$D = \frac{3}{2}\,\frac{r'\,T}{E\,t} - e\,r'\,t_0,$$

in which the Smith formula for deflection, due to T, is given, in order, presently, to compare numerical results.

In this case,

T = tangential stress, for width, t, at crown of horizontal arch of depth 1 ft., due both to water load and temperature change. When in compression it is positive; when in tension, it is negative.

r' = radius of extrados (= 135 ft. for Wooling Dam).

e = coefficient of expansion for change of temperature of 1° Fahr. = 0.000 0055 (Smith).

t_0 = number of degrees Fahrenheit of change in temperature above or below an assumed mean. For rise of temperature, t_0 is positive; for a fall, it is negative.

If the tangential stress due to water load, is denominated as T_w, and that due to change, T_0, then T_w is always positive, but T_0 can be positive or negative. Also, since t_0 can be positive or negative, there are four cases, all of which were carefully provided for in the foregoing formula. Careful attention must be

* *Proceedings*, Am. Soc. C. E., October, 1921.

† *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), pp. 79–87.

given to the algebraic signs. When D is positive, it indicates a radial deflection down stream.

As Smith gives the modulus for the horizontal arch,

$$E = 2\,000\,000 \times 144 \text{ lb. sq. ft.},$$

it will be used in this formula. For a rise of temperature of 20° Fahr., on substituting numerical values and multiplying by 12 to reduce to inches,

$$D = 0.000\,00844\,\frac{T}{t} - 0.178$$

in which D is inches. For a fall in temperature of 20° Fahr., change the sign of 0.178. T and t have the same values as before, t being in feet, and T in pounds.

In Table 2, Columns 5 and 8 are computed by the foregoing formulas. The other columns are filled out from Table 1 for the Wooling Dam, not fixed at the base. For t_0 positive, the quantities for water load and temperature are algebraically added. Thus, the total deflection and thrust are due to both causes. For t_0 negative, change the signs of u and T, under "Temperature changes", and add algebraically to the values of u and T, respectively, in the third and fourth columns.

TABLE 2.

		Water Load and 20° Fahr. Rise of Temperature.			Water Load and 20° Fahr. Fall of Temperature.		
d, in feet.	t, in feet.	Total deflection, in inches.	Total thrust, T, in pounds.	D, in inches.	Total deflection, in inches.	Total thrust, T, in pounds.	D, in inches.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0	2.2	+ 0.092	+ 71 430	+ 0.087	+ 0.632	+ 117 770	+ 0.630
18.3	3.42	+ 0.085	+ 107 190	+ 0.096	+ 0.357	+ 72 210	+ 0.356

As the third decimal figure in the values of u in Table 1 cannot be relied on, the results for deflections (Columns 3 and 5 or Columns 6 and 8) compare very well. Similar results follow from use of the quantities pertaining to the dam fixed at the base. This should tend to give confidence in the formula for D and its applications.

A more accurate formula for D will now be written, by replacing the first term for deflection, due to T, by $c\,\dfrac{p\,r^2}{E\,t}$, and the last term by, ert_0,

$$D = c\,\frac{p\,r^2}{E\,t} - ert_0$$

in which D is in feet, and, as before, r is the radius of the center line of an arch, on which the normal unit pressure, due to the combined water load and temperature change, p, is positive when directed toward the center; otherwise, it is negative. For a given central angle and a value of $\dfrac{t}{r}$, the value of c is to be taken from C Table 1.

On solving for $(p\,r)$, we find,

$$(p\,r) = \frac{E\,t}{c\,r}\,(D + e\,r\,t_0),$$

all dimensions being in feet. For a water load and rise of temperature, t_0 is positive; for a water load and fall of temperature, t_0 is negative.

Some of the results for the Barren Jack Dam will now be examined. On December 24th, 1908, with reservoir empty, the temperature was 87° Fahr.; and the deflection was zero. On August 10th, 1909, with reservoir full, the temperature was 60° Fahr., and the deflection, at a point 17 ft. above the base, was 0.36 in. In this case, there was a fall in temperature of 27° Fahr., thus

$$D = \frac{0.36}{12} = 0.03 \text{ ft.}$$

$$t_0 = -27$$

At the point 17 ft. above the base, the author gives: $r = 78$ ft., $h = 10$ ft., $t = 4$ ft.; whence, $2\,\phi_1 = 58°\,40'$, $\frac{t}{r} = 0.0513$, and, therefore (C Table 1), $c = 1.65$, for an arch with "fixed ends".

Let $E = 2\,500\,000 \times 144 = 360\,000\,000$ lb. per sq. ft.; $e = 0.0000055$; therefore, $r\,e\,t_0 = -0.01158$, and $(D + e\,r\,t_0) = 0.01842$. Substituting numerical values in the formula,

$$(p\,r) = 206\,100 \text{ lb.}$$

The deflections under the water load and a fall of temperature are both down stream, giving compression at the extrados, tension at the intrados, from bending moment at the crown, which is negative.

From C Table 3,

$$a = 0.160 \text{ for water load;}$$
$$a = 0.170 \text{ for temperature.}$$

Let,

η_w = deflection from water load,

η_0 = deflection from fall of temperature.

Both these are unknown, but the following relation is true:

$$\eta_w + \eta_0 = D.$$

The total moment at the crown from both deflections, can be written:

$$M_0 = -\frac{E\,t^3}{r\,h}\,[0.160\,\eta_w + 0.170\,\eta_0]$$

An assumption will have to be made as to the values of η_w and η_0, expressed in terms of D, in order to effect a solution. Fortunately, the Barren Jack Dam and the Wooling Dam have nearly the same dimensions, and by reference to Table 1, it may be inferred that the deflections for the Wooling Dam, from water load and a fall of temperature, of 27° Fahr., are nearly the same; so that it will be assumed that the same relation holds for the Barren Jack Dam. Assume that, $\eta_w = \eta_0 = 0.5\,D$, therefore,

$$[0.160\,\eta_w + 0.170\,\eta_0] = \frac{1}{2}\,[0.160 + 0.170]\,D = 0.165\,D.*$$

*If, for a much greater fall of temperature, it was estimated that $\eta_w = 0.4\,D$; then, since, $\eta_w + \eta_0 = D$, it follows that $\eta_0 = 0.6\,D$, and $[0.160 \times 0.4 + 0.170 \times 0.6]\,D = 0.166\,D$. This illustrates the method to be followed in any case.

On substituting numerical values,

$$M_0 = -\frac{360\ 000\ 000 \times 64 \times 0.165 \times 0.03}{78 \times 10} = -146\ 200 \text{ ft-lb.},$$

$$\therefore p\ r - P_0 = \frac{-M_0}{r\left(1 - \dfrac{\sin \phi_1}{\phi_1}\right)} = \frac{146\ 200}{3.354} = 40\ 600 \text{ lb.}$$

$$\therefore P_0 = p\ r - 40\ 600 = 165\ 500 \text{ lb.},$$

and the unit stresses at the crown are,

$$s = \frac{1}{144}\left[\frac{165\ 500}{4} \pm \frac{6 \times 146\ 200}{16}\right]$$

$$= \begin{cases} +\ 668 \text{ lb. per sq. in. (compression) at the extrados;} \\ -\ \ 93 \text{ lb. per sq. in. (tension) at the intrados.} \end{cases}$$

The author derives,

$$\begin{cases} +\ 495 \text{ lb. per sq. in. (compression) at the extrados;} \\ -\ 242 \text{ lb. per sq. in. (tension) at the intrados.} \end{cases}$$

As another illustration of the decided influence of temperature change compare the deflection lines, Fig. 1, for December 24th, 1908, and for May 25th, 1909, at a point 17 ft. above the base. The fall of temperature is $87 - 47 = 40°$ Fahr.; and the deflection is, 0.32 in. Therefore, $t_0 = -40$, and $D = \frac{0.32}{12} = 0.0267$ ft. Following exactly the method used in the last example, writing $(0.160\ \eta_w + 0.170\ \eta_0) = 0.167\ D$, the unit stresses are found to be, at the crown,

$$\begin{cases} +\ 460 \text{ lb. per sq. in. (compression) at the extrados;} \\ -\ 226 \text{ lb. per sq. in. (tension) at the intrados.} \end{cases}$$

In this case, the thrust and bending moment at the crown are $P_0 = 67\ 300$ lb. and $M_0 = -131\ 600$, respectively. The great decrease in the thrust and a smaller (numerical) decrease in the bending moment, as compared with previous values, accounts for the great differences in unit stresses. Note that the unit tension at the intrados (226 lb. per sq. in.) is much larger than the value (93 lb. per sq. in.), as computed for the preceding case.

The horizontal arch considered, was taken as "fixed at the ends", in order to compare the results with those of the author. Since this arch was only 4 ft. thick, and not tied at the ends with reinforcement, it is doubtless intermediate between an arch "fixed" and hinged at the ends; so that, properly, the solution should be made for both cases, and intermediate values for the unit stresses written, depending on the conditions at the ends as constructed.

As to the confidence to be placed in results, it may be noted that the theory for water load alone is exact, but the theory of the influence of temperature changes is approximate. As first outlined by B. A. Smith, M. Am. Soc. C. E.,* the latter theory is open to some objections; but, as it is the best that has been proposed, this theory was adopted; particularly as it was believed that it gave close approximations to temperature stresses in arched dams. There is

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 2027.

another matter of importance which affects the accuracy of computed stresses from observed deflections, namely, the influence of vertical cracks in the masonry. Such cracks must close before arch action takes place, and there is a deflection during this closing when cantilever action alone is exerted. The total observed deflection is made up of the part due to the closing of the cracks and the part corresponding to the dam exerting both full arch and cantilever action. The formulas do not take account of the deflection due to closing of the cracks, and not completely of the subsequent deflection, since the dam is under action as a cantilever at the beginning of this later deflection. If the total deflection is used in the formulas, the dam is assumed to be without cracks at any stage. If it was possible to observe the deflection and temperature at the time of closing of any cracks, then the subsequent deflection can be regarded as the value of D in the formula, but t_0 must be taken as the difference between the temperatures (with the proper sign) at the time of closing of the cracks and the time of the final observation when the deflection is greatest. If the total deflection, including that corresponding to the closing of the vertical cracks, is taken as the value of η in the formula,

$$(p\ r) = \frac{\eta}{c} \frac{E\ t}{r}$$

the value of $(p\ r)$ will always be too great. In fact, for quite large cracks, it is easy to conceive of the deflection due to the closing of the cracks being the greater part of the total deflection, so that $(p\ r)$, as computed, should have more than double its true value. Of course, if $(p\ r)$, as computed, should prove to be greater than its value for full water pressure at the base of the dam, the absurd result would show at once, either the influence of wide cracks or inexact observations.

It is thus seen that the author's analysis, in addition to the approximations introduced by substituting a flat parabolic arc for the circular arc, suffers from the lack of a precise method for estimating the part of the water load sustained by the arch. At the crest of the dam, it is never attempted. However, it is easy to supply this omission, since $(p\ r)$ can be readily computed, as already shown, either by the use of the author's formula for deflection or by the writer's more precise formulas for either fixed or hinged ends.

The arch thrust due to rib-shortening alone is given in a precise manner by the author's Equation (14), in connection with Fig. 4. Similarly, the author's Equation (18), in connection with Fig. 5, gives a precise estimate of the thrust due to temperature changes. Many of the results of C Table 2, expressed in terms of $\frac{t}{h}$, were compared with those of the author for temperature thrust and found to agree very well, thus affording a mutual check. It must be borne in mind that such values of H_t pertain to a free arch and do not include the influence of the reactions of the cantilevers. Both influences must be included to find the thrust for the arch regarded as a part of the dam.

In conclusion, it may be stated that the author has done good service in calling attention to the importance of a proper interpretation of the observations of deflections of curved dams. Such observations should be made with extreme

care, or they may be misleading, remembering that minute changes in deflection correspond to appreciable changes in stresses. Further, daily observations of the temperature of the air should be recorded, and the times for observations of deflections should be at periods when there is not much change in temperature.

B. F. JAKOBSEN,* Assoc. M. Am. Soc. C. E. (by letter).†—Referring to the discussion of the deflection curve of the Salmon Creek Dam, the author states:‡

"A cantilever fixed at the base * * * would have the line of zero deflection as a tangent, approximately as shown by a typical cantilever deflection curve in Fig. 2."

As the writer showed§ in discussing the author's paper, on "Gravity and Arch Action in Curved Dams," the deflection curve of a dam like the Salmon Creek Dam is not vertical at the base, but makes a considerable angle with the vertical due to the shear deformation. The author's statement is approximately true for ordinary beams, in which the length of the beam is considerable compared with its height; when the length of the beam is considerably less than its height, the deflection due to shear exceeds the deflection due to bending, as shown in Table 15 and Fig. 32, of the writer's discussion referred to previously.

The angle, α, at the base of the Salmon Creek Dam, on the assumption that the dam acts as a cantilever, is found from the writer's Equation (45):

$$t\,g\,\alpha = \frac{d\,y_h}{d\,x} = \frac{1.2\,S_h}{144\,G\,b}$$

in which $S_h = 31.3$; $h^2 = 31.3\,(H - x)^2$ lb. for 1 ft. width of dam; G is the coefficient of rigidity $= \frac{E}{2.4} = 1\,040\,000$ lb. per sq. in.; $b =$ the base $= 42$ ft. and $H = 160$ ft.‖

This gives $\alpha = 0°\ 0'\ 33''$, at the base. The typical cantilever deflection curve, as shown by the author in Fig. 2 is given in the correct shape in Fig. 32 of the writer's discussion to which reference has been made.

The lower 28 ft. of the dam may be considered as a rectangular section, the base being 42 ft. and the height 28 ft., as shown in Fig. 3. The top of this 28-ft. section has moved down stream $\frac{3}{8}$ in., and this is accounted for by the author by cracks which he claims have been produced in the up-stream face of the concrete and close to bed-rock. He then says:¶

"Such cracks, of course, will extend only for a comparatively short distance into the dam body, and the water-tightness is insured sufficiently by the increased compression stresses near the down-stream side."

* Designing Engr., San Joaquin Light and Power Corporation, Fresno, Cal.

† Received by the Secretary, December 23d, 1921.

‡ *Proceedings*, Am. Soc. C. E., October, 1921, p. 274.

§ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 99.

‖ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 99 (Fig. 31).

¶ *Proceedings*, Am. Soc. C. E., October, 1921, p. 274.

If the dam has developed cracks in a horizontal plane near the base, then the total deformation of the concrete is practically negligible and that means that the crack in the up-stream face must be:

$$0.375 \times \frac{42}{28} = 0.56 \text{ in.}$$

If this crack exists it must extend practically through the dam, and seepage would most likely take place at this point. The probability would be in favor of one large crack instead of several small cracks.

To account for the ⅜-in. movement 28 ft. above the base of the dam, the author calculates that a uniformly distributed load of 20 000 000 lb. would be required, and, in doing so, entirely neglects the shear deformation. The shear diagram is a triangle 28 ft. high with 25 400 000 lb.* as a base and, therefore,

$$S_h = 25\,400\,000 \frac{H - x}{H}$$

and the deflection due to shear alone is,

$$y'_h = \int_{x=0}^{x=28} \frac{12 \times 1.2}{144\ G \times b} \times S_h\, d\,x = 0.815 \text{ in.}$$

The total deflection due to shear and bending is, therefore, 1.19 in., or 3.17 times as great as the deflection calculated by the author. The load distribution assumed by Mr. Noetzli seems very improbable. The more proper load distribution would be to assume a shearing force as a maximum 28 ft. from the base and as zero at the base, so that,

$$S_h = 25\,400\,000 \frac{x}{H}$$

This gives a deflection 6.34 times as great as that computed by Mr. Noetzli and, therefore, a maximum stress of 1 325 lb. per sq. in. instead of the author's 8 400 lb. per sq. in. This is on the assumption that the base is fixed, which, in the writer's opinion, is untenable.

The author has evidently overlooked the most interesting point on the deflection curve, that is, the knee at Elevation 1075 (Fig. 2). This point is deflected 0.625 in., while the point at Elevation 1095 is deflected only 0.540 in., or 0.085 in. less. If the fact that the dam below Elevation 1075 is not vertical is taken into account, the relative deflection is 0.185 in. in the 20 ft. of dam. The average thickness of the dam at this place is approximately 31 ft., so that if this deflection is due to bending with a uniform load, as the author assumes, there must exist in the down-stream face, at Elevation 1075, a vertical tensile stress of:

$$s = \frac{2\ E\ h}{L^2}\ y = 5\,950 \text{ lb. per sq. in.}$$

* Using $E = 2\,500\,000$, as the author does, the writer obtains 25 400 000 lb. instead of the author's 20 000 000 lb. and a tension of 8 400 lb. per sq. in., instead of the author's 6 600 lb. per sq. in.

in which,

$E = 2\,500\,000$ lb. per sq. in.;
$h = 31 \times 12$ in.;
$L = 240$ in.; and
$y = 0.185$ in.

If it is assumed, as seems more logical, that the beam is 40 ft. long, fixed at the ends, and uniformly loaded, and that the deflection in the middle is 0.085 in., then,

$$s = \frac{16\,E\,h}{2\,L^2}\,y = 2\,750 \text{ lb. per sq. in.}$$

There should be, therefore, according to the author's theory, a horizontal crack in the down-stream face at Elevation 1075. As no crack has been reported, the writer assumes that none exists.

The fact that no horizontal crack has developed in the down-stream face at Elevation 1075 affords an excellent example of the large deformation a concrete dam can undergo, without producing cracks, and, in spite of the fact that a tension of about 2 750 lb. per sq. in. should exist at that point according to the ordinary formula for bending. It shows that the ordinary bending formulas are entirely inapplicable.

In view of the fact that no cracks have developed in the visible down-stream face, there is no reason to expect any cracks in the up-stream face. It is very fortunate that Mr. Noetzli has applied his theory to the Salmon Creek Dam, as this affords a means of checking his analysis against known facts and shows that his assumptions of cracks in the up-stream face are not verified.

Regarding the accuracy of the deflection measurements, L. R. Jorgensen, M. Am. Soc. C. E.,* mentions the great difficulty of measuring such deflections accurately near the base of the dam, and any one familiar with such measurements will not fail to realize this.

The aim of the author, to determine stresses from deflections, is far too ambitious an undertaking with the present state of knowledge. The method may yield valuable and approximate information in the hands of one who fully understands the limitations imposed by the assumptions. In unskillful hands, the method is bound to lead to conclusions which cannot be substantiated and which are likely to be incorrect.

In the interest of scientific precision, the writer would suggest that phrases such as that used by the author, for example:†

"A further proof that this dam has developed horizontal cracks at the up-stream side is shown by the following calculations: * * *."

should not be used, unless the dam is known to have cracked. As expressed by the author it may be misleading.

In summing up, the writer can do no better in expressing his opinion than by quoting from the discussion, by D. C. Henny, M. Am. Soc. C. E., of the author's paper on "Gravity and Arch Action in Curved Dams":‡

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 319.

† *Proceedings*, Am. Soc. C. E., October, 1921, p. 274.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 121.

"The reason that the mathematical treatment by the author carries no conviction is that, owing to the complexity of the problem, it is extremely incomplete and ignores numerous important elements to which he himself. * * *, makes able reference."

CHARLES P. DUNN,* ASSOC. M. AM. SOC. C. E. (by letter).†—An appreciation of Mr. Noetzli's enthusiasm and his able efforts to solve a difficult problem, prompts the writer to add to the discussion, in the hope of being helpful.

The large amount of capital to be spent in projected water-control works in the near future makes it desirable that the study of arch dams should be continued, in order that engineers may accept improved methods of design as soon as possible. Even a slightly better understanding of the subject will save many thousands of dollars.

On account of the shrinkage of concrete on setting, and the variations of volume with temperature, it appears to be practically impossible to design an unreinforced arch dam, in which the cantilever stresses will not be excessive (at least from a theoretical standpoint), unless the deflection allowed by shrinkage is largely eliminated by grouting the cracks and construction joints or by closing narrow vertical openings in the dam when the temperature is slightly below the mean after shrinkage in the main body of concrete has taken place.

The writer favors the latter method because, as Mr. Noetzli has pointed out, if the grouting is poorly done, the dam is injured by an uneven distribution of compressive stresses and the introduction of bending moments in the arches. It has also been pointed out that it is impossible to know positively to what extent a joint or crack has been filled with grout, and attention has been called to the difficulty and uncertainty of building up a high grouting pressure due to the friction head of grout flowing in small cracks, and to the difficulty of forcing the crest up stream due to the leakage of grout from the last seam to be filled when sufficient pressure is applied to move the crest.

No agreement has been reached on the amount and importance of rock deformation under and at the abutments of the dam. These deformations are classed by different engineers from infinitesimal and negligible to appreciable and of consequence. It appears that, unless deflection measurements are complete, covering practically the entire surface of the dam, an unknown rock deformation would introduce error into the determination of stresses from deflections.

If complete analysis of stresses is to be made from deflection measurements, the existence or non-existence of cracks must be ascertained, and existing cracks must be located.

Engineers do not agree as to what extent the uncertain element of the "flow" of concrete or the change of the modulus of elasticity with time may enter into the determination of stresses from deflection measurements.

Mr. Noetzli has already shown‡ that in the ordinary type of arch dam the upper horizontal arches carry a greater load than is imposed on them directly by water pressure, the additional load being transferred to the upper zone by

* Designing Engr., Skagit River Power, Seattle, Wash.

†Received by Secretary, December 20th, 1921.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 1.

vertical beam action. He has worked out a method for determining approximately the distribution of load between the vertical beams and the arches by considering that the beams are supported throughout their length by arches of varying stiffness or ability to carry load. The writer is confused by the thought that, in addition to the foregoing assumption, it seems necessary to consider also that the arches are supported throughout their length by cantilevers of varying stiffness and that load may be transmitted horizontally from a region of flexible cantilevers to a region of stiff cantilevers by a portion of the arch acting as a beam. In other words, if the cracks are closed and the dam is acting as a whole, the deflection of any single point in the dam changes the stress in every horizontal arch and every vertical beam in the dam, which condition throws doubt on the applicability of the comparatively simple formula used by Mr. Noetzli to obtain the arch deflection. It seems that the use of this formula might introduce an error of some magnitude into the calculations for a dam built at an irregular site. In his evidently thorough study of the problem, Mr. Noetzli has no doubt covered this point.

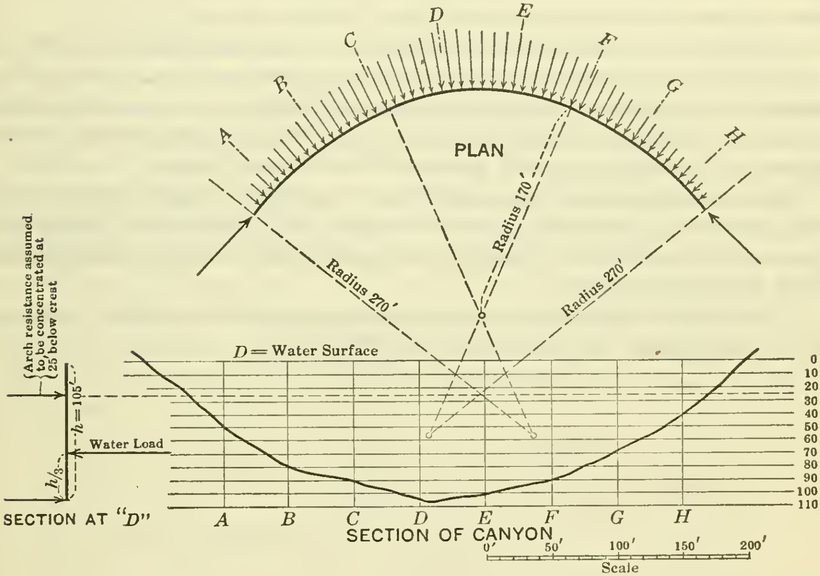

FIG. 8.

It appears to the writer that, in general, the arches in the usual type of dam have not a uniform normal load, for the following reasons:

1.—The upper arches are loaded by (*a*) a uniform normal load imposed directly by the water pressure, plus (*b*) an additional load imposed by the vertical beams, which additional load is greater near the crown than near the abutments. Mr. Noetzli's calculations show that a certain additional load (*b*) exists. This additional load will probably be greater in quantity than his calculations show, because of rock deformation and because of hydrostatic pressure under the dam. The effect of these uncertain deformations and forces will be to increase the condition of uneven loading of the arches.

2.—Take a zone near the middle of the height of the dam. The arches may carry a certain part of the load near the crown, which loading diminishes to zero as one goes along a horizontal plane to the side of the canyon, at which point all the load is carried by the cantilevers.

To illustrate this point an approximate calculation has been made of a hypothetical dam which is assumed to have no resistance as a cantilever, the water load being carried by vertical beams supported at the base by the foundation and near the top by an arch in a horizontal plane, all the resistance by arch action being assumed to be concentrated at one elevation. The site is the usual U-shaped canyon, as shown in Fig. 8. With this extreme assumption, the uneven loading of the horizontal arch gives a linear arch of maximum curvature at the deepest part of the canyon, the curvature decreasing to almost a straight line at the abutments. The three circular arcs occupy closely the position of the somewhat irregular linear arch.

The true condition in an actual dam must be such that the center line of pressure resulting from the loading of the horizontal arch slices will be somewhere between a circle and the hypothetical extreme shown in Fig. 8.

It appears to the writer that a deviation from the exact circular form, following as closely as practicable the true line of pressure of the elastic arch as determined by studies of existing structures, will effect an economy of material because of reduction of bending moments in the horizontal arches, without necessarily increasing the unit stresses now considered proper.

Such a deviation from the circular form concentrates a larger portion of the total curvature in the deeper part of the canyon, and, at a few sites, might make it economically advisable to substitute conical surfaces for the warped surfaces of the constant-angle arch.

A test of miniature dams covering this point would be extremely interesting and would probably develop some worth while data.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

THE CIRCULAR ARCH UNDER NORMAL LOADS

Discussion*

By B. F. Jakobsen, Assoc. M. Am. Soc. C. E.

B. F. Jakobsen,† Assoc. M. Am. Soc. C. E. (by letter).‡—The author has presented an interesting and valuable paper on an important subject. He seems to possess in an unusual degree the happy faculty of the born mathematician of presenting a complicated and highly mathematical subject in such a manner as to make it readable and, therefore, doubly valuable. Even a cursory reading of the paper affords an understanding of the assumptions made therein, the analytical methods used, and the methods given for using the formulas.

Equations (12) and (13) are general formulas and, therefore, should apply for any value of the radius, r. As a matter of fact, when r approaches infinity, and the central angle approaches zero, the two formulas do give the correct bending moments for a straight beam fixed at both ends and loaded uniformly with p lb. per sq. ft. From Equations (12) and (10) we have, writing x in place of ϕ_1:

$$M_0 = \frac{x - \sin(x)}{x} \; \frac{p\,k^2\,2\,x\sin(x)}{\left(1 + \frac{k^2}{r^2}\right)[x^2 + 0.5\,x\sin(2x)] - 2\sin^2(x)}$$

If the width of the canyon is L ft., then:

$$r = \frac{L}{2}\sin(x) \qquad \text{.......................... (20)}$$

since x is half the central angle. Also,

$$\sin(x) = x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5\,040} + \cdots\cdots$$

and for small values of the angle, x,

$$\sin(x) = x - \frac{x^3}{6} \qquad \text{.......................... (21)}$$

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* Discussion on the paper by William Cain, M. Am. Soc. C. E., continued from December, 1921, *Proceedings*.

† Designing Engr., San Joaquin Light and Power Corporation, Fresno, Cal.

‡ Received by the Secretary, December 14th, 1921.

For an angle of 60°, the error in Equation (21) is less than 1 per cent. Introducing Equations (20) and (21) in the equation for M_0 and dividing by x^4:

$$M_0 = \frac{2\,p\,k^2}{6} \frac{1}{-\frac{x^2}{18} + 4\,\frac{k^2}{L^2}\left(2 - \frac{4}{3}x^2 + \frac{x^4}{12} - \frac{x^6}{54}\right)} \quad \text{.........(22)}$$

and for $x = 0$,

$$M_0 = \frac{p\,L^2}{24}$$

and this is the equation for the bending moment in the center of a straight beam fixed at the ends and loaded uniformly with p lb. per sq. ft.

Likewise, Equation (13) for the moment at the abutments becomes, after introducing Equations (20) and (21) and dividing by x^4:

$$M = \frac{2\,p\,k^2}{6} \frac{2 - \frac{7}{12}x^2 + \frac{x^4}{24}}{-\frac{x^2}{18} + 4\,\frac{k^2}{L^2}\left(2 - \frac{4}{3}x^2 + \frac{x^4}{12} - \frac{x^6}{54}\right)} \quad \text{.........(23)}$$

and for $x = 0$,

$$M = \frac{p\,L^2}{12},$$

which is the formula for the bending moment at the end of a straight beam loaded uniformly with p lb. per sq. ft.

Equations (22) and (23) may be used for computing the moments for any angle likely to occur in dam design. As already pointed out, Equation (21) is correct within 1% for central angles of 120 degrees. For small values of the central angle, Equations (22) and (23) give nearly exact values.

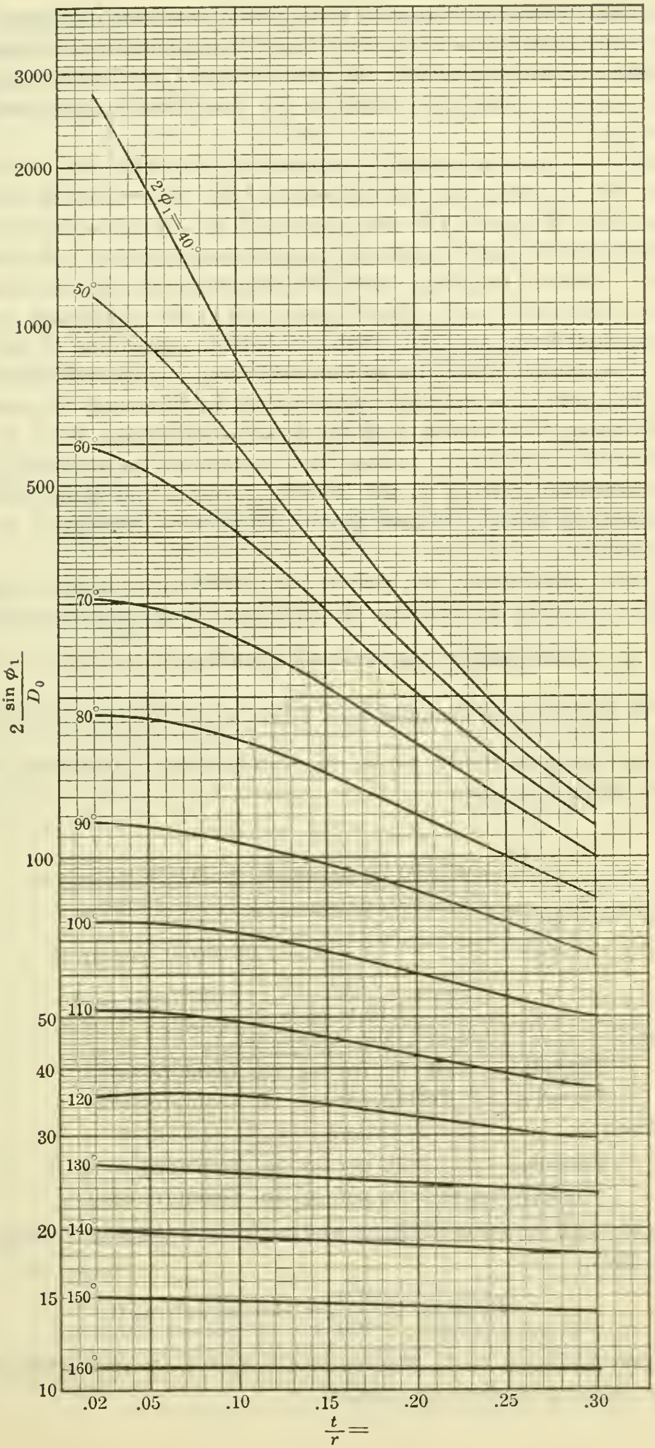
From Equations (22) and (23), the relative values of the bending moments can be more readily seen than from the original equations. It is evident that the bending moment at the abutment is always considerably larger than that at the crown, but as x increases this difference decreases. The statement* that "In a fixed arch, the bending moments at the arch abutments resulting from the thrust, H, are twice as large as at the crown," is seen to be incorrect; for example, for a central angle of about 120°, that is, x is nearly one, the bending moment at the abutment is less than 1.5 times the moment at the crown, and for larger values of the central angle this is further reduced. It may also be noted, that Equation (14) for the shear may be obtained from Equation (13) by differentiation, as is the case for a straight beam.

Equation (15) which gives the deflection at the crown for an arch fixed at the abutments, was also checked by substituting Equations (20) and (21), dividing by x^6, and setting $x = 0$, when Equation (15) becomes:

$$\text{Deflection} = \frac{p\,L^4}{16\,E\,t^3}$$

which is the deflection in the center of a straight beam fixed at the ends and loaded uniformly with p lb. per sq. ft.

* "Deflections and Stresses in Arch Dams", by F. A. Noetzli, Assoc. M. Am. Soc. C. E., *Proceedings*, Am. Soc. C. E., October, 1921, p. 266.



3000
2000
1000
500
100
50
40
30
20
15
10
$2 \frac{\sin \phi_1}{D_0}$
$2\phi_1 = 40°$
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
.02
.05
.10
.15
.20
.25
.30
$\frac{t}{r} =$

FIG. 8.

No doubt the same result can be found from the formulas given for the hinged arch; the writer does not believe that the assumption of a hinged arch is ever satisfied in dams, although the assumption of fixed ends certainly is, whenever no excessive tension is found at the abutments by the formulas for fixed arches.

The author assumes a constant modulus of elasticity and neglects the deformation due to shear and the influence of the water soaking of the up-stream face. In a thin arch, this should not lead to any appreciable error and, in the writer's opinion, the long, slender arches near the top of a dam are those most difficult to design properly, since little assistance is afforded from cantilever action. When no tensile stresses are found at the abutments, and when the central angle is large, say, 120° or thereabouts, the spreading of the foundation must be negligible, especially as the total force on the abutment is small for a thin arch, and it seems to the writer that, in this case, the assumption of fixed ends agrees very closely with the actual conditions. With the nearly exact formulas of the author, it is possible to determine the stresses in the top of the dam instead of relying on the Rankine formula and using low stresses in the computations in order to take care of the uneven distribution of stresses through the section.

To facilitate calculations, the writer has plotted the author's Table 2 on Fig. 8. This was done by plotting on semi-logarithmic paper the values of $\frac{2 \sin \phi_1}{D_0}$ for the various angles, one curve for each value of $\frac{t}{r}$, and then interpolating. To illustrate the formulas with a thin arch, suppose $\frac{t}{r} = 0.02$ and $2\phi_1 = 40°$, and let $p = 864$ lb. per sq. ft., $r = 50$ ft. and, therefore, $t = 1$ ft. The Rankine formula gives:

$$r' \times p' = s \times t = r \times p$$

$$s = \frac{864 \times 50}{1} = 43\ 000 \text{ lb. per sq. ft.} = 300 \text{ lb. per sq. in.}$$

The author's formulas give:

$$p\,r = 864 \times 50 \qquad = 43\ 200 \text{ lb. per sq. ft.}$$

$$p\,r - P_0 = 2\ 750 \times \frac{864}{12 \times 50} = 3\ 980 \text{ lb. per sq. ft.}$$

At the crown:

Extrados = 440 lb. per sq. in. (compression)
Intrados = 108 lb. per sq. in. (compression)

At the abutment:

Extrados = 57 lb. per sq. in. (tension)
Intrados = 607 lb. per sq. in. (compression)

For an arch with the same thickness and radius and the same loading, except that $2\phi_1 = 180°$,

$$p\,r - P_0 = 6.7 \times \frac{864}{600} = 14.4 \text{ lb. per sq. ft.}$$

Therefore, practically, $pr = P_0$, the bending moments are practically zero, and the Rankine formula applies very nearly.

As an example from an actual dam, we may consider the Kerckhoff Dam.* This is a constant-angle arch dam, approximately 110 ft. high, with Taintor gates, 14 ft. high, on top. At Elevation 970, with water standing 10 ft. above the top of the Taintor gates:

$$h = 25 \text{ ft.};$$
$$t = 9.88 \text{ ft.};$$
$$r' = 205 \text{ ft.};$$
$$r = 200 \text{ ft.};$$
$$\frac{t}{r} = 0.0494$$
$$2\phi_1 = 122°$$

The author's formulas for an arch fixed at the abutments give:

$$p \times r = 321\,000 \text{ lb.}$$
$$p \times r - P_0 = 2\,220 \text{ lb.}$$

Therefore, at the crown:

Extrados = 257 lb. per sq. in. (compression)
Intrados = 191 lb. per sq. in. (compression)

and, at the abutments:

Extrados = 156.5 lb. per sq. in. (compression)
Intrados = 300 lb. per sq. in. (compression)

The Rankine formula gives 225 lb. per sq. in. The maximum shear exists at the abutment; by the author's Equation (14), and assuming a parabolic distribution through the cross-section, it is only 2 lb. per sq. in., and the deformation due to shear, it would seem, would certainly be negligible.

At Elevation 900:

$$h = 95 \text{ ft.};$$
$$t = 289 \text{ ft.};$$
$$r' = 157.7 \text{ ft.};$$
$$r = 143.3 \text{ ft.};$$
$$\frac{t}{r} = 0.201;$$
$$2\phi_1 = 82°\ 40'.$$

This gives

$$p \times r = 935\,000 \text{ lb.}$$
$$p \times r - P_0 = 350\,000 \text{ lb.}$$

Therefore, at the crown:

Extrados = 357 lb. per sq. in. (compression)
Intrados = 75 lb. per sq. in. (tension)

At the abutments:

Extrados = 246 lb. per sq. in. (tension)
Intrados = 568 lb. per sq. in. (compression)

* See the writer's article, "Design and Construction Features of the Kerckhoff Dam", *Engineering and Contracting,* June 8th, 1921, p. 565.

The Rankine formula gives 225 lb. per sq. in. Computing the shear at the abutment as before, we find the maximum shear equals 83.3 lb. per sq. in. Although the maximum compression has about doubled, the shear, in this case, is forty times as great as previously stated.

It is worth noting in this connection that the water load gives moments of opposite signs to the moments due to a rise in temperature (see the author's Figs. 2 and 4).

A temperature increase of 5° Fahr. for the Kerckhoff Dam, at Elevation 900 and with $E = 144 \times 3\,000\,000$; $e = 0.0000055$, gives:

$$H_0 = 128\,000 \text{ lb.} = 30.7 \text{ lb. per sq. in.}$$

and, since for any angle, ϕ,

$$H = H_0 \cos \phi$$

there is obtained for the temperature stresses alone:

At the crown:

Extrados = 47.3 lb. per sq. in. (tension)
Intrados = 108.7 lb. per sq. in. (compression)

At the abutments:

Extrados = 172 lb. per sq. in. (compression)
Intrados = 126 lb. per sq. in. (tension)

Combining the water loading due to 95 ft. of head with the loading due to a temperature rise of 5° Fahr.:

At the crown:

Extrados = 310 lb. per sq. in. (compression)
Intrados = 34 lb. per sq. in. (compression)

At the abutments:

Extrados = 74 lb. per sq. in. (tension)
Intrados = 442 lb. per sq. in. (compression)

It is quite evident, therefore, that grouting the dam under pressure or closing it at or near the end of the coldest season, as suggested by L. R. Jorgensen,* M. Am. Soc. C. E., must be beneficial. A comparatively large increase in the compressive stresses is not a matter of great importance, and the method evidently makes it possible to reduce the undesirable tensile stresses.

That the influence of shear will be much greater with thick arches than with thin arches with the same central angle may be seen by comparing the shear in the two examples given by the author.†

In the first example:

$$p\,r - P_0 = 0.00265\,p\,r$$

Since $t = 4$ ft.,

$$P = 0.25\,p\,r$$

in which P is in pounds per square foot, and if parabolic distribution of the shear is assumed, then

$$S = \frac{1.5 \times 0.00265\,p\,r \times 0.866}{4} = 0.00086\,p\,r$$

* "Improving Arch Action in Arch Dams", *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 316.

† *Proceedings*, Am. Soc. C. E., October, 1921, p. 291.

in which S is in pounds per square foot, and, therefore,

$$\frac{P}{S} = 290$$

Therefore, the shear is certainly negligible compared with the normal stresses.

From the second example, we have:

$$p\,r - P_0 = 0.219\,p\,r$$

and since $t = 40$ ft.,

$$P = 0.0223\,p\,r$$

in which P is in pounds per square foot, and the shear is

$$S = 0.0071\,p\,r$$

in which S is in pounds per square foot, and, therefore,

$$\frac{P}{S} = 3.14.$$

In the first example, the maximum shear is about one-third of 1% of the normal stress, while in the latter case, the shear is about one-third of the normal stress, or relatively speaking, nearly one hundred times greater than in the first example.

If r is assumed to be the same in both cases, but p in the second case is ten times as great as in the first case, because t is ten times greater, then the maximum shear in the two cases is:

$$\frac{0.00086}{0.071} = \frac{1}{82}$$

In the second case, the shear stresses are eighty-two times greater than in the first case.

It would seem, therefore, that for thick arches, when the central angle is not too small, the author's Equation (5) should include the elastic work for shear. This is:*

$$L = \frac{1}{2\,G} \int d\,x \int\int S^2\,dy\,dz$$

or, for a rectangular section of unit width, since,

$$G = \frac{E}{2.4}, \text{ and } d\,x = r\,d\,\phi$$

$$L = 2.88\,\frac{r}{2} \int_0^{\phi_1} \frac{S^2\,d\,\phi}{E\,t}$$

Also, in the thick arch, there is more likelihood of a considerable difference in temperature between the up-stream and down-stream faces, and the assumption of a constant modulus of elasticity is much more questionable, because the difference between the stresses in the up-stream and down-stream faces is considerable and much greater than is the case with thin arches. Finally, in actual dams, the thick arches are near the base and considerably affected by cantilever action and the weight of the concrete above.

In the example of the Kerckhoff Dam, the tension in the up-stream face at the abutment, at Elevation 900, would be 246 lb. per sq. in., if it is assumed that

* C. Bach, "Elasticität und Festigkeit", Third Edition, p. 349.

the arch sustains the entire water pressure. The arch would fail therefore if it was loaded as assumed; but if account is taken of the shear deformation and of the variability of the modulus of elasticity,* a different result would be obtained, and this arch would probably require a load several times greater than the assumed load before it would fail.

The author's Equation (15) gives the deformation at the crown for an arch fixed at the abutment. From this formula, we should be able to estimate the deflection of a free arch. For thin arches, the formula should give correct values, that is, values which agree with the modulus of elasticity of the material in the arch. For thick arches, the writer believes the correspondence would be much smaller for the reasons previously given. As an illustration of very large deformations in a concrete dam which has not produced cracks, the Salmon Creek Dam† might be mentioned. At Elevation 1 075, there is a very decided knee in the deflection curve, and this would require a vertical tensile stress of 2 750 lb. per sq. in., if the deformation is to be accounted for by deflection due to bending under the influence of a uniformly distributed load. In spite of this, no cracks have been reported in the down-stream face, and it is not likely, therefore, that any exists. The assumption generally made, that the deflection is due to bending alone, is not correct.‡ The deflection due to shear is likely to be several times greater than the deflection due to bending, so that the tensile stress, when correctly computed, would be, perhaps, one-third of the value previously given. If this stress really existed, it would not fail to produce cracks, and therefore it may serve as an excellent illustration of the great circumspection necessary when concluding, from the measured deflections, the magnitude and nature of the stresses in a large concrete arch.

It should also be borne in mind that the deflection which occurs the first time the dam is loaded is not an elastic deformation, or as expressed by Messrs. Eddy and Turner§:

"Initial loading, however, is certain to develop noticeable deviations from perfect elasticity because of shrinkage stresses developed in the hardening of the cast concrete. A few repetitions of loading largely eliminates such deviations, so that the theory of work and the elastic theory of deformation becomes applicable and proves a practical and precise method of treatment."

To this should be added the influence of the internal heating due to the setting or curing of the cement and also the influence of lateral stresses which in a large concrete dam cannot be altogether negligible.

The author has solved an important problem in dam design in an exact and sufficient manner, and his solution will be of great help to engineers who have to design large arch dams.

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* See the writer's discussion on "Gravity and Arch Action in Curved Dams", by F. A. Noetzli, Assoc. M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 95.

† *Proceedings*, Am. Soc. C. E., October, 1921, p. 275, Fig. 2.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 99, especially Fig. 32.

§ "Concrete-Steel Construction", Part I, p. 76.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

A REVIEW OF IMPORTANT DEVELOPMENTS IN THE SCIENCE OF CADASTRAL RESURVEYS AS EXECUTED BY THE UNITED STATES GOVERNMENT, WITH ETHICAL DISCUSSION THEREOF

Discussion*

By Messrs. E. M. Douglas and D. E. Hughes.

E. M. Douglas,† M. Am. Soc. C. E. (by letter)‡.—It is to be regretted that the author did not include in his paper a description in greater detail of the latest methods of making original cadastral surveys as well as resurveys. The writer's experience leads him to believe that all survey work by the General Land Office since the contract system was discontinued, has been well done by methods which may be accepted as models for other surveyors.

The writer is particularly interested in the references to the methods for determining true azimuth. The desirability of reporting true bearings should be impressed on every engineer who has long lines to run for cadastral surveys, boundaries, railroads, highways, or for public works of any kind. Too many of such surveys have been based on magnetic bearings, with no clue to the amount of the local variation of the needle; an oversight which produces much confusion and uncertainty when retracements are required. If engineers could be made to realize how easy it is to determine true azimuth by observations on the sun or on Polaris, more of them would use such methods. In reasonably clear weather, Polaris can be seen at any hour of the day with a good transit telescope.

To find Polaris in broad daylight, three things are essential:

1.—The telescope must be accurately focused. The proper focus can be found by observing the star at night and marking the telescope draw tube for future reference.

2.—The star's apparent altitude must be known within about 5 min. of arc, which can be found from tables. The U. S. Geological Survey will send such a table free, on request.

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* This discussion (of the paper by Howard Richards Farnsworth, Assoc. M. Am. Soc. C. E., published in November, 1921, *Proceedings*, but not presented at any meeting of the Society), is printed in *Proceedings*, in order that the views expressed may be brought before all members for further discussion.

† Topographic Engr., U. S. Geological Survey, Washington, D. C.

‡ Received by the Secretary, December 8th, 1921.

3.—The true bearing of Polaris at the time of observation must be known within less than half a degree.

The angular distance of Polaris from the true pole for any hour angle may be found from tables published by the U. S. Geological Survey, and the approximate direction of true north may be computed from a previous determination of azimuth or obtained by a magnetic needle, proper allowance being made for declination.

With the telescope properly focused, set off the computed altitude of the star on the vertical arc and turn the telescope to its estimated bearing. If the star is not seen at once, turning the telescope to the right or left a fraction of a degree without changing the altitude angle will usually bring it into view if the weather is favorable.

For general use the method described by the author for observations on the sun can be simplified somewhat without appreciable loss in accuracy.

In railroad or highway surveys, it is not necessary to observe the sun directly through a colored glass, nor is any prism or other special attachment required, but the sun's image focused on a piece of paper held 2 or 3 in. from the eyepiece of the transit, can be bisected with an error of less than 1 min. of arc. The image of cross-wires shows up plainly when the telescope is in focus.

When observations on the sun are made rapidly, the mean of the times and of the angles measured can be used for the computation. The time may be 1 or 2 min. in error without appreciably affecting the results.

Observations on Polaris for azimuth are somewhat more accurate than those taken on the sun, but if they cannot be taken during the day, it is better to use the sun.

D. E. HUGHES,* M. AM. SOC. C. E. (by letter).†—This paper is an instructive exhibit of the survey methods of the General Land Office, but the methods are not all as scientific as the title implies. On page 432‡ it is stated that all the temporary corners on a trial meander are moved in the same direction and through distances proportional to their distances from the point of beginning, measured along the meander lines. That statement approximates the probable truth, only as the meander approximates a straight line.

The author assumes that the method is similar to that discussed by Leonard S. Smith, M. Am. Soc. C. E., in 1912,§ which is logical, although long, and gives a different result in that the temporary corners are not moved along parallel lines, nor through distances proportioned by the Land Office rule, as given by the author.

A generation ago, a similar problem was presented in *Engineering News* and some other paper simultaneously, and the Profession was surprised to find that few of the many replies were correct. Nearly all followed the rule exhibited by the author, or calculated as is done in balancing a closed traverse. A few used the same method as Mr. Smith, but the prize winner attained

* Los Angeles, Cal.

† Received by the Secretary, December 12th, 1921

‡ *Proceedings,* Am. Soc. C. E., November, 1921.

§ *Transactions,* Am. Soc. C. E., Vol. LXXV (1912), p. 429.

the same results by a shorter course, showing that all the temporary corners are to be moved in directions making constant angles with straight lines or diagonals drawn from the point of beginning to them, and through distances proportional to the lengths of those diagonals.

The reasoning, as remembered, was that, in the absence of evidence to the contrary, the field work in both surveys had to be assumed as correct in determinations of deflections and applications of chains, and therefore, the discrepancy between the point attained by the trial lines and the existing original corner is to be attributed entirely to a difference in orientation, a difference in chain lengths, or a combination of both.

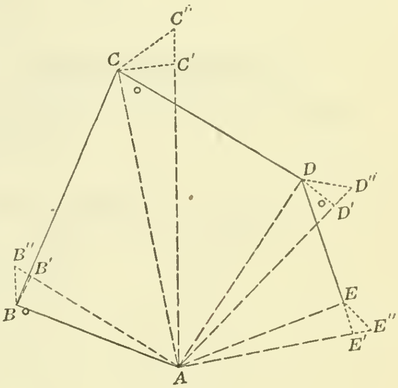

FIG. 13.

Suppose the surveyor assumes a meridian and begins at a known point, A, Fig. 13. Following the recorded courses and distances, he runs his trial line through B, C, D, to E, near which he finds the original corner, E'', and notes its course and distance according to his own survey, from E. He then determines by observation, calculation, or plotting, the directions and distances of E and E'' from A, according to his own survey.

If E is not on Line $A\ E''$, his survey must be revolved about A until it is, the rotation being the angle, $E\ A\ E''$. By that process, B, C, D, and E traverse arcs to B', C', D', and E'. The arcs being of equal angular measure, their chords, BB', CC', etc., are proportioned to the radii, AB, AC, etc., and make equal angles with them.

If the point, E', after revolving, is not coincident with E'', his chaining must be altered until it does coincide, the factor to be applied being the ratio of AE'' to AE. By that process, in which all lines are lengthened, or shortened as the case may be, B', C', D', and E' traverse Lines $B'\ B''$, $C'\ C''$, etc., to B'', C'', D'', and E'', these lines being proportional to the radii which they alter.

It has now been observed that in the triangles, $B\ B'\ B''$, $C\ C'\ C''$, etc., the angles at B', C', etc., are equal, and that the adjacent sides are proportional, each side being to the corresponding side of another as are the radii or diagonals from A to them. The triangles, therefore, are similar. Hence, Lines $B\ B''$, $C\ C''$, etc., along which the temporary corners are to be moved to accomplish the required change in orientation and chain length in one operation, are themselves proportional to the diagonals from A and make equal angles with them.

If the author's rule was applied, the temporary corners would be moved to the points marked by small circles, thus requiring that some lines be revolved to the left and others to the right, and that some be lengthened and the remainder shortened. It hardly seems possible that such erratic procedure, if clearly explained, would be sanctioned by any Court.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

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BUCKLING OF ELASTIC STRUCTURES

Discussion*

By George Paaswell, M. Am. Soc. C. E.

George Passwell,† M. Am. Soc. C. E. (by letter)‡.—For the first time there is presented before the Society a rational precis of column action, unfortunately, by a mathematical physicist, using the word, unfortunately, in the sense that the language he speaks is foreign to most of his readers. The importance of the subject, as well as of the matter presented, justifies an attempt to annotate the contents of the paper, both as a matter of criticism and as a matter of elucidation to readers interested in column theory.

Fundamentally, the author classifies all column action into three, more or less characteristic, actions: The true buckling—where flexure is the principal action—the author terms "astatic equilibrium"; where distortion is directly proportional to the load, as in the short column, or in ordinary transverse flexure, the related equilibrium is termed "orthostatic equilibrium"; and a mixed condition containing both types of equilibrium is termed "heterostatic equilibrium." Summarized briefly in other terms: Orthostatic, in which $\frac{l}{r}$ is less than 20; heterostatic, in which $\frac{l}{r}$ lies between 20 and 300; and astatic, in which $\frac{l}{r}$ is greater than 300. The values of $\frac{l}{r}$ are, of course, very approximate, but are those generally used to distinguish the column types.

Taking up the work presented by the author in the logical order of development, the basis of the analysis is the energy function, the resilience factors as found in a stressed column or thin rod, as the case may be. The development of the work equations may have been predicated on the energy function of Lord Kelvin, with probably more facility in comprehension by engineering

* This discussion (of the paper by H. M. Westergaard, Esq., published in November, 1921, *Proceedings*, but not presented at any meeting of the Society), is printed in *Proceedings*, in order that the views expressed may be brought before all members for further discussion.

† Section Engr., Public Service Comm., First Dist., New York City.

‡ Received by the Secretary, December 1st, 1921.

readers, but the methods used are undoubtedly better and are the basis of the most modern research in mathematical elasticity.

The voluminous data presented in forming the equations may be necessary from the standpoint of a mathematical physicist—as far as establishing the requisite requirements of rigor—but they are confusing to the engineer. Briefly, the configuration of the elastic curve of columns, slender rods, or thin plates, plane or curved, is determined by a set of parameters, u_m, etc. If the shape of the elastic curve is given by an expression, $y = u \sin a x$, then, any variation in the parameter, u, affects the amplitude of y, but not its phase, exhibiting one character of the parameter.

The equations for work are known to engineers in the form of Castigliano's theorems—the theory of least work and its corollaries following from the well known principle of least action of D'Alembert. Although his theorem should apply essentially to conservative systems*, yet the results may be extended to systems which are not conservative. Astatic systems probably may be regarded as such.

The final useful form of the parameter, as given by Formula (74), follows from the minimum property, and the "effect" which may here be termed the moment, is built up of terms of Formula (74), obtaining the author's fundamental equation. The form as given in Formula (125) involves the introduction of primary eccentricities and, as the author points out, is the basis of most existing formulas.

Proceeding from Formula (74), the formulas of Table 1, and those in Formulas (7) to (10), are established. This should be noted, however. Formula (13) is predicated on very small displacements. The exact expression takes the form:

$$M_n = C_n \, c\, n\, a \, (x + K)$$

where $c\, n$ is the modular cosine, an elliptic function, and characterizes the phenomena grouped under the general term, elastica. For small values, cn becomes a cosine, and $K = \frac{\pi}{2}$, giving the sine form as previously noted. The form, as given, does not lend itself to development in the Fourier series. The higher forms of buckling given by the larger values of n imply necessarily finite displacements, so that the trigonometric series would be in serious error. The modular functions with the values of K adjusted to have the periods fixed by the values of n, gives the more correct forms of the elastica. However, as the coefficients in the Fourier series form a rapidly converging series, the higher terms play no rôle in the analysis, and the equations presented give substantially reliable results.

If one concedes that it is possible to give rational column formulas to cover so-called heterostatic action, the author has completely covered the field of column formulation. The writer will endeavor to show that it is not feasible to establish a formula which will rationally exhibit column action, but that, nevertheless, a mode of procedure does exist, which permits a rational mode of column design.

* See, for example, Byerly, "Generalized Co-ordinates".

It may be well at this point to review briefly previous attempts to analyze column action and to see what results have been obtained.

Euler pointed out in 1778 that vertical columns do not break under vertical loads by mere crushing, but that flexure of the column will be found to precede rupture. He proceeded to develop the equations which determine the maximum load to hold a column at a given deflection. Lagrange expressed the limiting load equations in a similar fashion. Robinson* points out that experimental research fails to check Euler and Lagrange. In discussing the results of Hodgkinson's tests, Pearson suggests that there may be some value in the Eulerian hypothesis when it is properly modified so as to include the effect of compression. It is interesting to note here that the analysis of Prof. Westergaard shows that when compression is allowed for†, the form of the equations in heterostatic action are not changed.

E. Lamarle‡ notes that up to a certain ratio of length to diameter, the maximum load ought to be calculated from the formula:

$$P_0 = \frac{E\,F\,S_0}{n}$$

where S_0 is the greatest stretch that can be given without passing the elastic limit; F is the area of the section; and n is Poisson's ratio; the ratio is denoted by K in the paper. Beyond this ratio, the maximum load is given by the Euler expression. It is noted that these expressions seem to reconcile the Euler theory with the existing experimental data.

Rankine proposed the expression bearing his name. He states that this expression was first suggested by Tredgold and afterward revived by Gordon who determined the values of the constant from Hodgkinson's experiments.

A very theoretical study of the action of slender rods is given by Clebsch in his "Theory of Elasticity." The equation of the elastic curve of the rod is determined from the solution of the differential equation:

$$E\,I\,\frac{d^2\,\phi}{d\,s^2} = C \sin\phi$$

ϕ is the angle which the tangent to the curve at any point a distance, s, from the terminus makes with any fixed direction. The solution of this equation involves the elliptic functions. An exhaustive analysis of this curve, covering all the higher systems of stability—the higher criteria of astatic equilibrium—has been given by A. E. H. Love, in "A Treatise on the Mathematical Theory of Elasticity," in which an interesting analogy (Kirchoff's analogy) with the motion of a pendulum is illustrated. The question of the elastic stability of systems is also discussed in the text, but, as the rods are slender ones, the treatment is practically that of Euler.

The introduction of the linear law by the late T. H. Johnson, M. Am. Soc. C. E., and the parabolic expression of the late J. B. Johnson, M. Am.

* "A System of Mechanical Philosophy", 1805.

† *Proceedings,* Am. Soc. C. E., November, 1921, p. 505.

‡ "Memoire sur la Flexion du Bois", *Annales* des Travaux Publics de Belgique, IV, pp. 1–46 (1846).

Soc. C. E., need not be discussed here, except possibly to quote an excerpt from the paper of Mr. T. H. Johnson*, as follows:

"Before closing this article, it will be well to revert to the older formulas and the reasons why they fail to give satisfactory results * * *. Gordon fell into error, not only from paucity of experiments at his command, but also by following Tredgold's assumption that a certain portion of the area is required to resist flexure. Under this assumption the modulus of compression would remain as a factor in the equation for all length ratios, but with diminishing influence, becoming zero only when $\frac{l}{r}$ becomes infinite: whereas it now appears that the modulus of compression ceases to be a factor when $P = \frac{K}{3}$ [K is the Euler factor] * * *."

In discussing a paper† by the late A. J. DuBois, M. Am. Soc. C. E., Mr. T. H. Johnson has hinted at a possible solution of the column theory using the energy developed as a working basis. This, it is noted, has been accomplished by Professor Westergaard in his paper, utilizing the results of modern research, as given in the attached Bibliography (Part VII).

The rapid growth of column theories and their vague connection with the increasing volume of test statistics made it necessary to draw a distinction between the column of theory and that of practice. Not a sharp or clearly defined distinction, but one sufficient to limit the theory and still provide an opening for empiric adjustment. William Cain, M. Am. Soc. C. E., defines this theoretic column as the "ideal column", and proceeds to effect its theoretic study.‡ His definition of the ideal column is: "prismatic homogeneous columns, having the force, P, applied at one end, in the direction of the axis or line through the centers of gravity of the cross-sections."

He points out a vital fact in the analysis of the column as carried out by Euler and one which has not been clearly enunciated before, namely, that Euler's formula gives the load at which bending just begins. In this connection, Mr. W. E. Lilley, an earnest and brilliant student of the column, both as a mathematical and as an engineering problem, has demonstrated that Euler's formula considers bending only and ignores the effect of the direct load as a compressive force on the transverse sections.§ This, of course, is quite clear from an analysis of the expressions given in Professor Westergaard's paper.

Amplifying the theory of the ideal column, Anson Marston, M. Am. Soc. C. E., has extended the analysis to cover the case of a load of known eccentricity, obtaining the so-called secant expression for the stress.

The converse problem of the "practical column" has been discussed¶ by J. M. Moncrieff, M. Am. Soc. C. E. Intricate expressions were obtained which Professor Cain reduced to the standard secant form.

The results of experiments are always somewhat disappointing. There are, of course, numerous uncertain elements which influence the strength of

* "On the Strength of Columns", *Transactions*, Am. Soc. C. E., Vol. XV (1886), p. 517.

† "A New Formula for the Strength of Columns", *Transactions*, Am. Soc. C. E., Vol. XXVII (1892), p. 69.

‡ "Theory of the Ideal Column", *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898) p. 96.

§ *Engineering*, July 2d, 1909.

¶ *Transactions*, Am. Soc. C. E., Vol. XLV (1901), p. 334.

a column, such as type of form, details, processes of manufacture, fabrication, etc., all of which may not be of calculable nature. The influence of any or all of these elements may be obviated by a wise selection of forms; but this is rarely possible. New tests bring with them new problems to be solved by further experimentation. The ideal function of tests is to supply certain physical constants, which, when substituted in formulas mathematically derived, determine at once the strength factors of a given type of column. Practically, tests fall far short of performing this function and are usually applied as determining the usable stresses in a column of given material and proportions. This is a restricted field for tests, but to the present time they have not justified their extension to broader fields.

The late A. P. Boller, M. Am. Soc. C. E., added a discouraging note: "In my opinion no formula will ever give satisfactory results, and dependence must be placed upon experimental charts."

It is seen that not much progress has been made in the development of column formulas and this paper may well be taken as a last word in the attempt to formulate column action. At this point, one may well ask "Is a rational column formula possible?"

Briefly, a column is an engineering structure subjected to a compressive force of a determinate character and to a flexure absolutely indeterminate and unpredictive with any mathematical certainty. This, of course, refers to columns presumably axially loaded. The introduction of flexural stresses occurs in a manner which can only form a matter of conjecture. The piece may not be straight due to fabrication, shipping, or erection methods. The loading may not be applied at the geometric axis of the column due to the manner of the connections or other details of the structure of which the column forms a member. The column may be detailed so that the individual shapes comprising the column entity do not act as a unit, so that the distortions under load are not uniform (this is not to be confused with astatic action or equilibrium); or it may be a heavily rolled shape the metal of which does not possess uniform elastic properties.

In a number of cases, where there is a transverse load, or where known moments are introduced at the column ends, it is possible to predict the flexure with reasonable accuracy. For the present, the standard column type—an independent structural unit—is under discussion. Tests serve a general purpose in giving clues to column action, but like theory itself, they must be interpreted with a clear apperception of the physical improbability of defining column action rigorously.

Emphasizing the fact that despite elaborate analysis, there is no way of determining the flexure moment of what may be termed simple heterostatic action, that is, no transverse loading, it seems inevitable that one must answer the leading question, "Is a rational column formula possible?" in the negative. Since some method of analysis is necessary, the proper mode of procedure would seem to be, to find out under what conditions, referring, of course, to unique cases, the value of the moment, M, can be made determinate.

Stated in slightly different language, the problem for each individual case examined seems to be to learn just what is the true position of the applied

load. This eccentricity would lead to the selection of the proper formula, as given by Professor Westergaard, or to some of the simplifications now in vogue. Again, in a number of cases, it is possible to determine just what moment is introduced into the column by its adjoining members. If such moment is calculable, it is the moment to be used in the general formula.

The column is usually treated as a separate and distinct unit taking its load, presumably axial, but no other stress, from its neighboring units. This is the ideal, but far from the actual, condition. Every structural member, whether beam, column, or only a connecting detail, is a part of a system of framework, and it is through the distortion of the frame by various types of loading that the several members, comprising the frame, are stressed. By a study of the frame itself, therefore, it may be possible to make determinate the factor, M, in the column formula. A few examples may illustrate the possibilities of this mode of analysis.

The simple bent, as shown in Fig. 15, is a common type of construction, and usually the girder is assumed to rest lightly on the column, that is, it is designed as a simple beam with free supports. On the other hand, the designer may purposely introduce such details as will fix the corner, making it rigid, thus transferring a moment into both the column and the girder. It is possible, of course, that in the actual case such details will be used as will develop a joint intermediate between the free and the fixed ones, the designer assuming a simply supported beam and a column taking no moment from the joint.

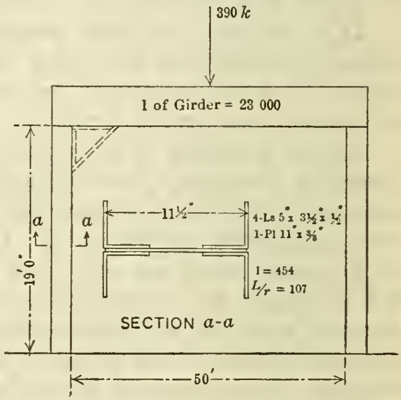

Fig. 15.

It is important to note that the joint, as a simple connection, places no restraint on the deflection of the girder and the girder must throw a substantial, if not the entire, portion of its load on the inner edge of the column. One may safely assume that the entire load will thus be placed. The eccentricity of the load is thus measurable and M can be determined. Assign arithmetical values to the members shown in Fig. 15. The value of the moment is $185 \times 0.48 = 89$ ft-kips. Following the method ordinarily used and obtaining the permissible stress from the building code formula of New York City,

$$\left(p = 15\,200 - 58\,\frac{L}{r}\right)$$

the allowable unit stress is 9 000 lb. per sq. in., which the area and slenderness ratio of the column just satisfy. Using the formula:

$$F = \frac{P}{F} + \frac{M_c}{I}$$

and taking an allowable stress for f of 16 kips per sq. in., and with the other functions of the section as noted in the diagram, solving for M, there is found a value of 45 ft-kips., only half the moment as determined from the

eccentric location method. Although it is true that one may say that the entire concentration of the load on the column edge is only a matter of conjecture, it is a possible and, more emphatically, a probable condition and gives a calculable premise which is a vital point in rational and consistent design.

Take an alternative condition: The joint is made a fixed one, thus bringing the girder reaction concentric with column section. Assume that the girder is loaded, as shown in Fig. 15, with a single concentration at its mid-point. Computing the moments from *Bulletin No. 8,* University of Illinois, "Analysis of Statistically Indeterminate Structures by the Slope Deflection Method," by Messrs. Wilson, Richart, and Weiss, on the assumption that the detail fixing the joint is dimensioned so that it reinforces the column section to a point 2 ft. below the girder, it is found that the column section must be such as to carry a moment of 160 ft-kips. Clearly, it is not enough merely to call a joint fixed. It must be made so, and the column must be designed to meet the moment. On the other hand, if a detail is introduced which, in effect, fixes the connection, care must be taken to see that the column can safely take the moment induced. The writer is aware that this question is amply covered in most treatises on secondary stresses, but it is quite doubtful whether, in ordinary structural design of simple frames, the effect of the joint is properly examined. As a matter of comment, however, it seems safe to say, that, in this case, also, it is possible to compute a value of M and that resort to a column formula is unnecessary.

Several other cases might be mentioned, such as building columns, framing between girders, viaduct columns, and columns which are subjected to a definite transverse load, such as subway columns and the like. Many more types will undoubtedly occur to the reader. It is sufficient to say that, in engineering practice, in the majority of cases, it is possible to find a calculable moment in the column member.

The column formula is predicated on an uncertain flexure, while it has been noted that it is possible to observe the moment to which the ordinary column is subjected. It seems, therefore, a rational method of design to make provision for the stresses which can be directly computed, using such permissible unit stresses as tests on short compression blocks exhibit, or tension tests, since these give about the same result as the compression tests. It may be objected that this method of design ignores the true column action induced by the accidents of fabrication or erection. This objection, although a valid one, may be applied to all structural units. If correct analysis has been used in developing a section to fit into a given structure, with proper provision for flexure, where such flexure can be calculated, the accidental stresses must be assumed to be taken care of in the factor of safety.

This method demands a high degree of alertness on the part of the designer. The deformations of the entire structure of which the column forms only one unit must be carefully studied. The standard column formula is a blanket allowance for all such uncertain loadings. The rational method suggested gives the designer no such royal path to a simple design. It is a postulate of good engineering design that the details should fully develop the structural members which they interconnect. The converse of this may now

well be emphasized. Structural members should be designed to carry safely the stresses which the details bring to them. Too often this is not done. There is too much child-like faith in "axial loads", "free supports", etc. It is true that in monumental structures a correct apperception of the conditions is had, and the details and the main sections are designed with consistency; but this is not so in structures of every-day design. Joints are made fixed by heavy details to secure a rigid structure, while the individual members are treated as separate and distinct units.

Two conditions may form an exception to the suggested method of design. Cases may occur where, as far as a thorough study can determine, a column is axially loaded with no outside induced flexure. Since this is the type of column which is usually tested, it may be safe to say that column formulas predicated on tests of similar formed columns are rational ones to use. The results of Professor Westergaard's investigations indicate that the Rankine expression is well founded*. In this connection, it may not be amiss to state that a series of tests on framework would give more profitable results than tests on columns alone.

The second exception is an important one. Throughout the analysis of the author's paper, and in engineering design in general, the metal is assumed to have uniform elastic properties. The heavy rolled sections do not possess such uniformity, and low ultimate and low useful limit points are found in columns assembled with heavy shapes. The use of metal of this character will give a section of low average resistance in comparison with a section of the same area but composed of lighter shapes. For this condition, a study of the report of the Special Committee on Steel Columns and Struts† will indicate just what should be used in the way of safe stresses. This exception, where there is a way of calculating a flexural stress, merely affects the total permissible stress, the proper formula to be used in no way being affected by the fact that the ultimate stress is lower than that found for thin rolled sections.

One may say in conclusion that, although it does not seem possible to discover a rational column formula, a rational method of column design does exist, but that a more detailed study of the structure is required than is ordinarily given. This objection, however, cannot be considered a libel against the method suggested. In the choosing of a column section, only half the problem is solved. The column details are vital, possibly more vital than the selection of the section members, as disastrous failures have indicated. A rational mode of design permits a rational mode of detailing. A well-knit consistently designed and detailed column contains a far greater factor of safety, even though the accidental stresses usually attributable to so-called column action have been neglected, than the column designed in accordance with some of the numerous formulas, with the vague rule-of-thumb methods of proportioning the details.

* See, also, "A Review of Column Formulas for Bridge Design", *Engineering News-Record,* March 10th, 1921, p. 431, etc. The suggested formula is:

$$p = \frac{16\,000}{1 + \dfrac{L^2}{13\,500\,r^2}}.$$

† *Transactions,* Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 1583.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

STREAM POLLUTION AND SEWAGE DISPOSAL
A SYMPOSIUM
Discussion*

By Messrs. Glenn D. Holmes, Rudolph Hering, C. M. Baker, P. H. Norcross, and Leonard S. Doten.

Glenn D. Holmes,† M. Am. Soc. C. E.—The papers and discussions on stream pollution and sewage disposal have been of particular interest to the speaker since, at Syracuse, these problems have been studied for some time for the purpose of improving the sanitary conditions of the watercourses throughout the city, and of Onondaga Lake into which these streams discharge.

The intercepting sewer system, on which construction was started some years ago, is practically completed. The watercourses which required deepening in order to permit interception of sewage from the lateral sewers without admitting backwater from the streams, have been improved and lined with concrete to insure permanency.

Both tanks and fine screens of the types described by Mr. Hammond‡ and Mr. Skinner,‡ as well as many other processes, have been considered as methods of sewage treatment at Syracuse.

The sewage testing station, at which several types of settling tanks, filters, activated sludge units, grit-chambers, etc., were operated, furnished many data of pertinent value. These data together with those secured regarding sludge disposal, the volume, fluctuation of flow, and character of the sewage, as well as the character and condition of the water of the streams and lake, were of great assistance in reaching conclusions regarding the method of treatment best suited to the local conditions.

The method of treatment adopted includes degritting, coarse screening, and plain sedimentation in tanks equipped for continuous or frequent removal of sludge. The sludge is to be pumped about two miles to the lagoons of the Solvay Process Company and after intimate mixture with the waste liquors, will be precipitated and buried in the lime banks. These waste

* Continued from December, 1921, *Proceedings*.

† Chf. Engr., Intercepting Sewer Board, Syracuse, N. Y.

‡ *Proceedings*, Am. Soc. C. E., December, 1921, pp. 618 and 625.

liquors are germicidal and are of sufficient volume to disinfect thoroughly more than four times the quantity of sewage sludge which will be produced. The solids deposited from the industrial wastes are thirty to forty times greater in volume than the sludge solids, which insures complete and effective burial. This method of sludge disposal is unique and precludes the possibility of creating objectionable conditions in the vicinity of the lagoons, the treatment plant, or Onondaga Lake.

Before submitting the proposed method of treatment to the State Department of Health for approval (the approval has now been given), Harrison P. Eddy, M. Am. Soc. C. E., was asked to review the studies and conclusions and make such further investigations as he deemed necessary to enable him to report and recommend the method of treatment best suited to the sewage of Syracuse. It is gratifying to state that Mr. Eddy concurred in the recommendations.

In connection with the work at the testing station, an investigation was made to determine the relative effect of detention period and velocity of flow on the deposition of suspended solids. The detention period was found to be the controlling factor and velocities of flow within the limits of the experiments, which ranged between 12½ and 150 ft. per hour, had no effect on the clarification or removal of matter carried in suspension.

The percentage of removal is dependent to a large extent on the strength of the crude sewage, and this should be kept in mind when comparing or interpreting the results of treatment of different sewages. The term, "percentage of removal," is too frequently used without due consideration of the strength of the crude sewage.

A removal of 60% was obtained in ¾ hour with Syracuse sewage which contains an average of about 270 parts of suspended solids per million. The contributing factor in the attainment of this high efficiency, with the comparatively short detention period, was the frequent removal of the sludge, precluding septic action.

Rudolph Hering,* M. Am. Soc. C. E.—With reference to the remarks by Mr. Eddy,† the speaker was asked, about 41 years ago, to report on the European sewerage systems for the National Board of Health, largely with reference to obtaining information regarding the separate system. Only two such systems were found in Europe, and these were for the Cities of Oxford and Reading in England. Continental engineers did not believe in the exclusion of rain water from sewers, much on the grounds stated by Mr. Eddy. In England, some discouragement was felt even by the officials of the two cities mentioned, one of whom stated that there was trouble in preventing the discharge of rain water into sewer pipes, and also the surreptitious discharge of sewage into the storm drains. The City Engineer of Oxford, Mr. White, stated that if he had it to do over again, he would use the combined system which was common in most other European cities.

In his report, the speaker distinctly discriminated between these two systems with special reference to their application in the United States. It was found

* Cons. Engr., Montclair, N. J.

† *Proceedings*, Am. Soc. C. E., December, 1921, p. 645.

proper to place these systems on a par. The application of the separate system has large possibilities in the United States, as compared with Europe, and engineers should not recommend the combined system indiscriminately for all cities. Many communities could not afford the expense of the combined system and were satisfied to start with a system for sewage removal alone, with great benefit to their comfort and health. In New Orleans, La., a complete double system was recommended at the outset, as it was found more economical than the combined system, because it cost less to pump the small volume of sewage into the Mississippi River even at high water, and to let the large quantity of water from the heavy rainfalls flow in the other direction into Lake Pontchartrain at ocean level.

The speaker would recommend the separate system for many of the cities of this country, particularly the smaller ones, for sanitary reasons, for otherwise they might not have any sewers until they could pay for the combined system.

Having studied the question of stream pollution and sewage treatment for about 45 years, the speaker wishes to express his satisfaction with the excellent papers presented on this subject. They show the great progress which has been made, and he hopes that in the next 40 or 50 years the progress will continue at the same rate.

About 35 years ago, the speaker was asked to study the Chicago sewage problem which had developed into a very serious situation. The question was whether to discharge the sewage into Lake Michigan, to purify it on land, or to discharge it into the Illinois River. At that time, little was known about bacteria. In fact, the first knowledge about bacteria in relation to sewage was acquired about the time the Chicago studies were being made. The available information, however, was not sufficient to aid in the solution of the problem.

In the United States, only the chemical analysis of sewage was generally reported, which by itself is not satisfactory. The speaker felt that the dilution question of disposal was an important one to consider for Chicago, not only on account of a possible lake disposal, but chiefly for the proposed channel which was to carry the diluted sewage to the Mississippi River. Information was available from a few places in Europe, particularly Paris, Hamburg, Dresden, Magdeburg, and a large number of cities in England. The best information, however, was from the work done on the Blackstone River in Massachusetts, and on the Desplaines River, into which the Chicago sewage was to be discharged, which information determined how much sewage could be put in running water without becoming objectionable.

All this information from Europe, Massachusetts, and Illinois was then plotted. It was astonishing to note the correspondence of these different data, and the indication from all of them that a dilution of from 2½ to 5 cu. ft. of water per sec. per 1 000 people appeared to be satisfactory.

As a result of this investigation it was recommended for Chicago that there should be introduced into the Drainage Canal about 4 cu. ft. of water per sec. per 1 000 people sewering into the Canal. The speaker felt that he was not making a mistake in recommending an expenditure of $30 000 000 to have this

channel built large enough to effect the dilution mentioned. In view of the slower velocity of water in the Chicago River and, consequently, the settlement of suspended sewage matter, a frequent removal by dredging was stipulated.

C. M. BAKER,* ESQ.—From Mr. Stevenson's discussion,† it is apparent that Pennsylvania has almost as good a Sanitary Law as Wisconsin; but, unfortunately, Wisconsin has not sufficient funds for the execution of its law. The abuse of sewers is a problem which cannot be over-emphasized. In practically all States it is the custom for the State boards of health to require the separate systems. In Wisconsin there has been in operation for 7 or 8 years a system of plumbing inspection. This system was inaugurated before the Bureau of Sanitary Engineering was established about two years ago.

Fortunately, in Wisconsin, the State Plumbing Inspector is very competent; in fact, he can almost qualify as an engineer. The Department has a certain number of State inspectors, and all the plumbers in the State are required to secure State licenses. Through this organization a complete system has been built up, and the situation is fairly well under control.

Mr. Jackson‡ was right when he stated that the people want results in stream pollution rather than continued investigation as to the extent of the pollution.

The Chairman of the Conservation Commission of the State of Wisconsin stated recently that at a National meeting of the representatives of the different conservation commissions of the States, he recommended that legislation be enacted prohibiting the discharge of polluting wastes into the streams—one of those suggestions for radical legislation.

The problem of industrial wastes has only been touched on, and very definite steps should be taken toward abating the existing polluted conditions. It seems to the speaker that possibly some of the funds expended in investigating existing conditions, the extent of the pollution, etc., might well be used for devising ways and means of eliminating or partly eliminating, at least, some of the most critical conditions with reference to pollution.

P. H. NORCROSS,§ M. AM. SOC. C. E.—The speaker concurs in the statements, made by Mr. Hatton,¶ regarding the necessity of disposing properly of the residual sludge from disposal plants. Experience has shown that the usual disposal of sludge is primarily the cause of adverse criticism from laymen and the public at large.

Atlanta, Ga., was the first large city in the United States to construct a sewage treatment plant using Imhoff tanks for digesting sludge. The city now has three plants with capacities of 3 000 000, 5 000 000, and 6 000 000 gal. daily, respectively. The largest plant is subject to some of the abuses and troubles caused by the misuse of sewers, and, in addition, its capacity is overtaxed. The dumping of the sludge in low areas surrounding this plant has tended to create a nuisance and to invite litigation against the city.

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* State San. Engr., State Board of Health, Madison, Wis.

† *Proceedings*, Am. Soc. C. E., December, 1921, p. 628.

‡ *Ibid*, p. 647.

§ Cons. Engr., Atlanta, Ga.

¶ *Proceedings*, Am. Soc. C. E., December, 1921, p. 635.

The speaker desires to express his appreciation of the opportunity of hearing the short, but interesting discussions on "Stream Pollution and Sewage Disposal."

LEONARD S. DOTEN,* M. AM. SOC. C. E. (by letter).†—Since sewage is one of the chief causes of stream pollution, it has become customary to associate the terms "stream pollution" and "sewage treatment", although they are antithical in meaning. All organic wastes, whether or not of human origin, industrial wastes, and the waste waters of mines, are the important contributing factors to the pollution of streams, lakes, and other natural bodies of water.

The introduction of water-carriage sewerage systems has greatly intensified the pollution of such bodies of water. For many years it was the universal practice to discharge both storm water and domestic sewage into natural watercourses, rivers, lakes, or harbors. As a result of this, these bodies of water, in the vicinity of large centers of population, became greatly polluted, and, in some instances, very foul. Small streams have become so polluted as to be nothing less than open sewers. Such practice is no longer justified, as effective methods for the treatment of sewage and industrial wastes are now available. Notwithstanding the progress that has been made in the art of treating such wastes, writers of treatises on sewage disposal devote much space to discussions on "disposal by dilution." This term is synonymous with "stream pollution." As long as sanitary engineers sanction the practice of loading streams with organic wastes "to the limit of toleration," little progress will be made in the elimination of stream pollution. There is great need for reform in this matter.

Engineers and sanitarians should start a movement for clean streams. Undoubtedly, it will be a difficult task to educate the public to appreciate the higher standard and its advantages. The trend now seems favorable, although not as positive as it should be. The educational work should be along three important lines: public health, industrial, and economic.

It is essential that streams and lakes be protected against pollution, as in the future, all large public water supplies are, or must be, derived from surface sources. There will be an increasing demand for larger supplies, due to higher per capita rates of consumption, especially as the cities and towns become more populous. As a consequence, some of the streams which are now becoming more and more polluted by sewage and industrial wastes will ultimately be required for water supply and industrial purposes. With this condition confronting us and the trend of engineering opinion becoming more averse to the use of "reconstructed" water for domestic supplies, it is not difficult to see that the time is coming when the treatment of sewage and industrial wastes will become practically universal in the United States.

Some of the States have adopted effective laws for the protection of streams against pollution. The State boards of health and other organizations having administrative authority to carry out these laws, should be aided by the Engineering Profession in every possible way.

* Capt., Quartermaster Corps, U. S. A., Washington, D. C.

† Received by the Secretary, January 3d, 1922.

Although there are several effective methods now in use for the treatment of sewage, the results are not in all cases satisfactory. The need is for standardization of practice, both in the design and the methods of operation of plants. Advancement in this work, like that in many other fields, must be made largely by perfecting details of existing processes or methods. Owing to the nature of the problem, it is extremely improbable that any process will be discovered, which will revolutionize the art.

Modern sewage disposal plants are not only "sewage treatment" plants, but can be operated so as to be in reality "sewage purification" plants, using the term, purification, in a relative sense, as it cannot be used in the absolute, even in water purification.

As generally understood to-day, sewage treatment accomplishes three objects: The removal of suspended matter, the reduction of that matter to a stable condition, and the oxidation of organic matter carried in solution. Treatment plants, therefore, should be designed so as to secure these results in the most satisfactory manner and at the least cost.

Sewage tanks now in use are highly efficient in the removal of suspended matter. It is not only possible to remove practically all settleable matter, but also a large percentage of the colloids.

The oxidation of organic matter in solution in the clarified liquid can be accomplished either by filters or by further tank treatment using the "activated sludge" principle.

As the non-settleable suspended organic matter (colloids) in sewage is a factor of considerable importance, amounting to as much as 30% of the total matter in suspension, it is important that a large quantity of this matter be removed by tank treatment before the secondary, or oxidation, process is begun. Plain sedimentation, obviously, is not effective in the precipitation of colloidal matter. It is necessary, therefore, in treating sewage containing a large percentage of matter in this form, to use a type of tank in which the processes of bacterial coagulation and sedimentation may be carried out most completely. These are Nature's processes of clarification. A good illustration of the advantages of this method of treatment over plain sedimentation may be found in the clarification of laundry wastes. Plain sedimentation alone has no appreciable effect in lessening the turbidity of the liquid. Such wastes may be left in a quiescent condition for days without showing evidences of clarification. On the other hand, laundry wastes may be very effectually clarified by passage through a tank in which the biological processes are well established and conditions are favorable to the precipitation of the flocculated matter. These wastes may constitute 75%, or even more, of the total sewage without deleterious effects on the effluent, if a suitable range of detention periods is maintained.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

WATER SUPPLY AND WATER PURIFICATION
A SYMPOSIUM
Discussion*

By Messrs. P. H. Norcross, H. Malcolm Pirnie, C. M. Baker, George W. Simons, Jr., M. N. Baker, and H. N. Bundesen.

P. H. Norcross,† M. Am. Soc. C. E.—In the broad field of mechanical filtration, several types of filters which might have been referred to, have not been mentioned by Mr. Whipple in his discussion,‡ namely, the drifting sand filters which are operated at Toronto, Ont., Canada, and filters of the pressure type, which are used in Atlanta, Ga. The filters at Toronto are operated successfully at a capacity about 40% higher than the usual gravity type. In Atlanta, there is located the largest filter plant of the pressure type in the United States. It has a rated capacity of 3 000 000 gal. of the old Hyatt type and of 18 000 000 gal. daily of the Continental Jewel pressure type. These filters are operated as gravity filters under about 30 ft. of head, and during the season of peak demand, have operated successfully at 100% overload. This discussion is not a brief in favor of this type of filter plant, but indicates its flexibility. At the present time, Atlanta is doubling its filter capacity, the program contemplating 21 000 000 gal. daily of the open gravity filter type.

In speaking of filtration Mr. Hazen§ referred to the character of water to be treated. On the eastern seaboard of the Appalachian and Blue Ridge Mountains, there are two main classes of water to be considered. The larger of the two classes are surface streams which carry heavy turbid red clays, and are located principally above the coastal plain. Below the coastal plain and adjacent to tide-waters, the usual plan of securing a municipal water supply is from deep wells. Pensacola and Jacksonville, Fla., Savannah, Ga., and others are using water of this character successfully.

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* Continued from December, 1921, *Proceedings*.

† Cons. Engr., Atlanta, Ga.

‡ *Proceedings*, Am. Soc. C. E., December, 1921, p. 654.

§ *Ibid*, p. 660.

Little trouble is experienced in the proper coagulation of water in the Appalachian and Blue Ridge sections, for during the greater part of the time there is sufficient alkalinity. The main difficulty is during certain seasons when there is a lack of alkalinity which must be provided artificially. In his comments, Mr. Weston* has mentioned Wilmington, N. C. A rather interesting sidelight on the water supply of Wilmington developed during the last summer. This city draws its water supply from the east fork of the Cape Fear River, the flow of which is much less than that of the western branch, the confluence of the two occurring at Wilmington. During the recent drought, the tidal water backed up beyond the intake of the city plant to such an extent that the supply contained approximately 1 200 parts per million of sodium chloride.

The speaker was impressed by the comments of Mr. Holmquist† regarding the decrease of typhoid rates. However, in commenting on water supplies of different municipalities, results should be compared with reference to the type of water treated. A comparison of typhoid rates between cities of the same size, in different parts of the United States, is not complete without all the information as to the type and character of water used.

H. Malcolm Pirnie,‡ Assoc. M. Am. Soc. C. E.—It has been said that coagulation basins which have a storage period of a few minutes, are adequate and preferable. It has also been said that the iso-electric point, as indicated by a P H value of 7, is the required hydrogen-ion concentration necessary for the best coagulation. These statements evidently come from experience with waters which coagulate rapidly and best at a hydrogen-ion concentration of P H = 7. Experience with other waters, however, has proven that long periods of coagulation and different P H values are sometimes required for good coagulation.

For many years, coagulation has been conducted with an acceptable degree of success, with the aid of standard methods of determining alkalinity and color by titration with methyl orange and comparison with color standards. Now, the new hydrogen-ion test has been developed. It is a new test and will give much interesting information, but it will not give at once a standard hydrogen-ion concentration to which all waters may be adjusted, to obtain the best coagulation.

There are waters in which the nature of solids, particularly organic colloids, varies from hour to hour and from season to season, notably in waters which are polluted with industrial wastes and sewage. These waters do not contain a constant percentage of given organic matter, and the colloids may vary in their electrical properties and degree of adsorption for the added coagulant. In these circumstances, it is essential, with present understanding of chemical treatment, to have a balance wheel in the process, to equalize the effect of variations in the nature of these colloids, and large basins are useful in this connection. One particular plant, where there is a storage of 8 days for the coagulation period, is producing an effluent much better than it was possible to

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 670.

† *Ibid*, p. 667.

‡ Cons. Engr. (Hazen, Whipple and Fuller), New York City.

obtain in former years with a storage period for coagulation of 4 hours; in fact, it is now possible to take the water from the river with a color which is sometimes about 150, dose it, let it pass through this basin, and after passing the basin, give it a secondary dose of a small quantity of alum, and obtain a color of zero, after filtration. It is interesting to note that at the start, before any alum is added, this water has a P H value of less than 7. Before a floc can be obtained, it is necessary to reduce that P H value to between 5 and 6, which is considerably below the so-called iso-electric neutrality point of P H = 7. It is evident, therefore, that there is not a definite P H value for all waters, which may be used to determine the required alum dose. The required P H value will vary, depending on the kind and condition of colloids present in the water.

Colloid chemistry has suggested certain ideas which can be applied to water treatment. The physical action of colloids may be used to remove them without the aid of chemicals. This has been demonstrated recently in treating a well water containing a considerable quantity of iron in the ferrous state, which is converted into the ferric state by aeration, and simply passed upward through a definite bed depth of gravel. The ferric iron colloids which are so small that they will pass through filter paper and will not be removed in appreciable quantities by storage for many hours, are absorbed on the surfaces of the gravel stones. The bed is graded from 4-in. gravel at the bottom to ⅛-in. gravel on the surface, and the depth of the bed is 9 ft. An iron reduction from 7 parts per million down to a trace, with an almost complete removal of colloids, is effected. The adsorption of the precipitated iron by the wetted gravel surfaces and the greater adsorption of the iron colloids on the surfaces of the precipitated iron, are responsible for this almost complete removal of iron from the water. Physical forces play the major part in the purification.

It must be borne in mind that each new idea simply provides another tool with which to work, and that it is not a solution of the problems which engineers have in hand. The determination of the P H value may help to fix the nature of the colloids in a particular water, which would be a step toward working out for that water a definite method of treatment, but a method applicable to one water will not apply to all waters, or even to water at different locations in the same stream with intervening pollution from sewage or industrial wastes.

C. M. Baker,* Esq.—Mr. Emerson's discussion† regarding the effect of gas-plant wastes on the taste and odor of chlorinated waters is interesting, especially since this condition has been a live question in the City of Milwaukee for some time. In the fall of 1918, before the speaker took up the work with the State Board of Health, exceedingly objectionable tastes and odors prevailed in the water supplied to the citizens of Milwaukee. In fact, it has been authentically stated that these conditions were so severe as to make the use of foods cooked in the water objectionable. The taste was ordinarily described as a medical taste, and did not resemble the taste of waters treated with an excess of chlorine. Furthermore, the tastes and odors occurred at infrequent intervals,

* State San. Engr., State Board of Health, Madison, Wis.

† *Proceedings*, Am. Soc. C. E., December, 1921, p. 662.

not continuously, and the quantity of chlorine applied appeared to have little, if any, effect on the production of the objectionable conditions.

An extensive investigation was conducted, largely by the chemists of the Water Department and the City Health Department, which consisted in the collection of samples of water from the rivers and harbors in Milwaukee, and also of different industrial wastes. These samples were treated with an excess of chlorine, which later was driven off by boiling, and the test was made by tasting or smelling the samples thus treated. It was determined in this way that the taste-producing properties were confined exclusively to those wastes from industries producing coal-tar derivatives; other wastes seemed to have no effect. It was further determined that phenol was the most objectionable substance in producing these conditions. The investigators claimed that by their method of testing, previously mentioned, the presence of phenol in a solution, as great as 1 part in 500 000 000, could be detected. At that time (1918), the State Board of Health and the Governor of Wisconsin were consulted. Numerous hearings were held, and finally by testing samples collected from Lake Michigan, the source of the trouble was traced directly to a Government phenol plant at Carrollville, about 15 miles from the Milwaukee intake. The matter was taken up with the Government and, in the fall of 1918, this plant was closed.

It was thought that the closing of the Carrollville plant had eliminated the objectionable conditions; but a slight recurrence of the odor was noticed in December, 1919, and again in March or April, 1920. This latter condition was more severe than that of December, and the State Board of Health was again called in consultation. At that time, the plant at Carrollville was operating on an entirely different basis, and was discharging no phenol wastes into the Lake. It was apparent, therefore, that the source of the pollution was elsewhere. The previous investigation, however, had failed to show the taste-producing quality in any of the samples collected in the harbor or the rivers. It was apparent, therefore, that the evidence was not conclusive against the two or three plants in Milwaukee known to produce wastes which were apt to cause the objectionable conditions. A rather complete investigation, therefore, was outlined and undertaken. Thousands of samples were collected from the rivers and harbor, and tested.

Three rivers enter the harbor at Milwaukee, namely, the Milwaukee from the north, the Menomonie from the east, and the Kinnickinnic from the south. The Milwaukee Coke and Gas Company discharges its wastes into a slip tributary to the Kinnickinnic River and the Milwaukee Gas Light Company directly into the Menomonie River. The Milwaukee River and the Kinnickinnic River are flushed by tunnels from the lakes; the Menomonie River, however, is not flushed.

In the testing of samples, it was soon learned that there was only occasionally taste-producing qualities in the samples collected from the harbor outlet. By continuing the tests up the stream, the Milwaukee River was eliminated as a factor, but rather intense concentration was found in the Menomonie River—coming from the east—particularly just below the Milwaukee Gas Light Plant. On one or two occasions the taste-producing

quality was observed in the water at the mouth of the Kinnickinnic River, and, on a few occasions, in the harbor outlet. A careful study of the relation of wind conditions with reference to the taste in the water supply indicated quite conclusively that the conditions necessary to cause tastes were a west wind, followed almost immediately by a southwest wind. Certain intensity and duration of the wind was also necessary. Furthermore, it was learned that samples collected from the harbor outlet showed taste on test only during westerly winds. It was concluded, therefore, that the conditions causing taste and odor in the Milwaukee water supply were: First, the accumulation of wastes from the Milwaukee Gas Light Company in the Menomonie River and from the Milwaukee Coke and Gas Company in the slip tributary to the Kinnickinnic River; and, second, by west winds carrying the accumulated pollution out of the harbor, followed by southwestern winds carrying the pollution to the water intake.

The solution suggested was to provide for the continuous discharge of the wastes, thus prohibiting the intermittent discharges caused by changing winds. The wastes from the Milwaukee Gas Light plant, therefore, were pumped into a sewer discharging directly into the Milwaukee River, which sewer is flushed daily. The slip which receives the waste from the Milwaukee Coke and Gas Company was dammed and a pipe carried back of the dam for a distance of about 40 ft., to provide for the gradual discharge of the waste from this slip. These changes were made about a year ago, and there has been no recurrence of the objectionable conditions.

The situation in Milwaukee has been extremely serious. It has been so serious and such publicity has been given to the city's experience that much difficulty has been encountered in securing the installation of chlorine plants for the treatment of public water supplies in the State of Wisconsin. Some citizens of Milwaukee wished the chlorine discontinued although the necessity of this treatment was clearly demonstrated by an occurrence in 1916. One night, an employee of the Water Department shut off the chlorine without the knowledge of the Superintendent of Water-Works, or of the Health Department, and the apparatus was shut down for about eight hours. There followed, during the next few days, between 50 000 and 60 000 cases of gastro-intestinal trouble, and within the next few weeks between 400 and 500 cases of typhoid fever with between 40 and 50 deaths—very conclusive evidence of what chlorine is doing for the water supply of Milwaukee.

One more point regarding the effect which this condition may have over the United States. In the fall of 1919, the State Board of Health started a movement in Sheboygan to secure chlorination of its public water supply. The sewage from the city is discharged into Lake Michigan without treatment, and the water of the city is taken from the Lake untreated. The typhoid death rate for Sheboygan was about five times that of the State as a whole, and about three times that of Milwaukee. Serious opposition developed in the city, however, to the installation of chlorination, and it was only after the Department of Health issued a definite order and enforced it that such installation was secured.

George W. Simons,* Jr., Esq.—The discussion of Professor Winslow,† treating of the reduction in the typhoid fever death rate, has been interesting to the speaker, but one or two points mentioned by him should be further amplified, especially by one familiar with health problems in the Southern States.

Health workers in the Southern States, and particularly those in the Southeastern States, are not so greatly concerned with the problems of water-borne typhoid infection as they are with infection from other sources. These States may be roughly classed as rural in comparison with the thickly settled Northeastern States the total area of which in some cases is far less than the area of many smaller counties of the Southern States. In a greater part of the southern regions municipal water supplies are taken principally from deep ground sources and, therefore, the chance of water-borne typhoid infection is considerably lessened. In all Southern States where soil-pollution activities have been conducted, the reduction of typhoid death rates has been clearly reflected in those areas. Therefore, the typhoid problem of the Southern States is largely one of rural sanitation, at this time. As these States become more thickly settled, however, and ground-water supplies become depleted or depreciated in quality and are replaced by surface waters, typhoid will become more of a water problem.

Professor Winslow has reproduced some interesting figures showing reductions in typhoid mortality rates in the registration area as they were originally, and, also, as they are now constituted. His remarks inferred that the recent admittance to the registration area of States having a lower sanitary standard was reflected by the lessening typhoid reduction in the present area, as compared with that of the original States. Unquestionably, the admittance of many Southern States into the registration area has had an effect on the rates, but, even so, one point deserves attention. Since 1910, fourteen States have been admitted to the registration area for deaths; of these, eight are Southern States, in which health activities are receiving more attention than ever before.

An examination of the typhoid mortality rates as issued by the Bureau of Census indicates that, during the period 1900 to 1910, the typhoid death rate declined 13.3 points, and, from 1911 to 1919, 10.5 points. During the latter period eight Southern States were admitted to the registration area.

Health work in the South is becoming more and more active, a fact which can be verified by an examination of the results accomplished. As stated previously, the typhoid problem in the South is largely one of rural sanitation, yet great strides are being made in the combat of this infection.

In Florida, for instance, the typhoid mortality rate was 27.8 in 1918; 18.4 in 1919; and 14.3 in 1920, which indicates a steady decline. The rate for 1921 will show an increase which has been a source of some apprehension to those studying it, but since the speaker has discussed the problem with workers from other States, the seriousness somewhat diminishes, because many States will experience a high typhoid rate this year; in fact, a representative of one of

* Chf. San. Engr., State Board of Health, Jacksonville, Fla.

† *Proceedings*, Am. Soc. C. E., December, 1921, p. 664.

the largest Northern States has stated that he felt the typhoid mortality in his State would almost return to the 1913 figure.

There is still a final point which should be referred to, namely, the fact that much of the typhoid in a tourist State, such as Florida, is imported from elsewhere; in other words, Florida is charged with an undue typhoid mortality. During 1920, seven typhoid deaths were non-residents.

M. N. BAKER,* ESQ.—A few years ago, in discussing the diminishing typhoid rate, the speaker cast about for a figure which if attained might entitle a city or State to be placed on a typhoid honor roll. The figure decided on was 5 for a city and 7½ for a whole State. The rate has fallen so much since then that, in its summary of typhoid fever deaths in 1920, in cities of the United States having more than 100 000 population, the *Journal* of the American Medical Association of March 26th, 1921, sets the typhoid honor roll mark at 2 deaths or less, per 100 000 population. With that low rate (taking into account a correction in a later issue) 11 cities appear on the roll, while 30 cities had typhoid death rates of 5 or less per 100 000. That is in striking contrast with the rate of 20 per 100 000 mentioned by Mr. Whipple† as that generally used some years ago in discussing the extent to which typhoid should be reduced in order to clear a city of the charge that the disease was due to the water supply. As the typhoid rate approaches 1 per 100 000 population, cities of less than that size have a zero rate now and then or, perhaps, for several years in succession. The latter has been true of Montclair, N. J., a city of about 30 000 population, where there has not been a death from typhoid for the past four or five years. Notwithstanding this absence of typhoid in Montclair, there has been much local agitation over the character of the water supply, although it is filtered and chlorinated. This shows what may be expected in many communities: Low typhoid or none at all, and yet more popular agitation over the water supply then when the typhoid rate was 20, 50, or even more.

With typhoid so largely reduced, there seems to be a chance of uncovering or exposing other areas of trouble—some of the more or less mysterious intestinal disturbances. Whether these are due to public water supplies is an interesting and important question which needs extensive and intensive investigation. The time seems to have passed when, in a progressive city which is utilizing the engineering and other technical knowledge now available, there need be great concern over typhoid, as far as water supplies go, provided only that the cities live up to the knowledge which is extant, both in the design and construction of water-works and in their operation and general practices as well.

Since this agitation in regard to water supplies in communities where typhoid has virtually vanished, comes very largely from the medical profession, or is backed by it, there seems to be occasion for urging on the medical men, if they are going to pursue that course and ask the communities to expend large sums of money for further water treatment, to make a careful study of their patients who have intestinal troubles, and try to find out some things which at present they do not know regarding these disturbances. In some communities, now and then, these intestinal troubles affect hundreds or thou-

* Assoc. Editor, *Engineering News-Record,* New York City.

† *Proceedings,* Am. Soc. C. E., December, 1921, p. 654.

sands of people in a short time, but produce no typhoid. That was the case in Montclair three years ago and, later, in Cambridge, Mass., which had a typhoid rate of 1.7 in 1919 and 2.7 in 1920. There is still plenty for engineers to study, but members of the medical profession should go further in their studies than they have yet done, if they are to ask engineers and the public to increase the already large expenditures to improve the quality of water supplies.

H. N. Bundesen,* M. D.—There is undoubtedly a great deal in the statement of Professor Winslow† that the typhoid rate in the United States is near that of European countries. The rates in this country are probably far closer to the European standards than Professor Winslow's figures would show. In Europe, where post-mortems are resorted to so frequently, the causes of death are given more accurately and if the same scrutiny pertained in the United States, many communities would have rates of 1 per 100 000.

During the past ten years, tabulation in Chicago shows that the average duration of typhoid is 21 days before death. In Chicago, when a typhoid death certificate is presented and the case had not been reported, and if the certificate shows that the person has only been sick two or three days, it is looked on with suspicion and is investigated. Of the ten death certificates held up by the Department during the past several years, the bodies were posted by the coroner, and the cause of death in each instance was abortion or similarly concealed conditions. It would be interesting if Professor Winslow could take the 1916 and 1919 figures which he has presented and ascertain how many of those deaths occurred among patients who had only been sick three or four days.

A question of vital importance to the health authorities of Chicago at the present time, has been presented relative to the use of chlorine in connection with the water supply. More than 500 000 lb. of chlorine are used in a year, and every day more than 800 000 000 gal. of water are pumped. At times, complaints are received regarding the taste of chlorine. The water supplied from Lake Michigan to a community surrounded as Chicago is, must be protected. The water is not filtered and, in consequence, chlorine is used to protect the people. The health authorities have not been able, at any time, to trace any injurious effects to the use of chlorine. It is true that at times people will be told by their family physician that the trouble is due to chlorine, but the speaker is of the opinion that they are simply told this for want of a better diagnosis.

Another feature which might be of importance is the presence of *B. Welchii,* which has been found in the drinking water before chlorination, and at times has been taken from the taps after chlorination. Of course, this bacillus is a spore bearer and is not killed with chlorine.

* Chf., Bureau of Water Safety and Typhoid Control, Dept. of Health, Chicago, Ill.

† *Proceedings,* Am. Soc. C. E., December, 1921, p. 664.

MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Acting Secretary prior to the final publication.

JAMES SIMPSON BROWNE, M. Am. Soc. C. E.*

DIED OCTOBER 22D, 1921.

James Simpson Browne, the son of the Rev. Faneuil Browne, a Presbyterian clergyman, was born on November 14th, 1862, in Indiana, Pa. He received his early education in the schools of Indiana County and was tutored by his father in the higher branches.

Mr. Browne entered on his career as a Civil Engineer with one of the pioneer parties of the Union Pacific Railway, and was employed on the location and construction of its line through the Dakotas, Wyoming, and Idaho. He was afterward engaged in the development of the elevated railways in Brooklyn, N. Y., and in the building of the Washington Arch over the Harlem River, New York City, at that time the largest steel bridge span in the United States. Later, he joined the forces of the late George B. Francis, M. Am. Soc. C. E., in laying out the West Shore Railroad along the Hudson River.

In 1889, Mr. Francis was engaged by the late E. P. Dawley, M. Am. Soc. C. E., as Resident Engineer of the Providence Terminal Company, which was organized to design, construct, and operate a Union Passenger Station to serve the railroads then entering the City of Providence, R. I., and now forming parts of the New York, New Haven, and Hartford Railroad System, and Mr. Francis brought Mr. Browne to Providence to assist him in that work.

When the station was completed, Mr. Browne was retained by Mr. Dawley, largely in connection with the abolition of grade crossings on the New York, New Haven and Hartford Railroad in Rhode Island and Massachusetts, and as Assistant in charge of maintenance work.

In 1903, a Division Office of the System was established in Providence, with Mr. Browne as Division Engineer. He served in that position until 1914, when he was made Assistant to W. J. Backes, M. Am. Soc. C. E., Engineer of Maintenance of Way, and moved to the headquarters of the Department at New Haven, Conn., where he served until his death.

Although Mr. Browne had had a wide and varied experience in railroad location and construction, having begun his career in what was then the Far West, under the strenuous conditions surrounding pioneer railroad location work, and having had a part in the construction of important engineering structures, he was essentially a student, and preferred research work in the quiet of his office or study, rather than the turmoil of the construction camp.

As Assistant to the Engineer of Maintenance of Way, one of his first and most important duties was to prepare a manual for the guidance of the employees, and the present "Book of Rules" of the Maintenance of Way Depart-

* Memoir prepared by H. L. Ripley and W. S. Nichols, Members, Am. Soc. C. E.

ment of the New York, New Haven and Hartford Railroad Company, is a monument to his devotion and loyalty. Devotion and loyalty are the very foundation of an engineer's training and, as a rule, are taken as a matter of course and hardly mentioned, but they were so conspicuous an attribute of Mr. Browne's character that they are the first qualities that come to the mind of his associates in the Profession, who thus pay spontaneous tribute to the man.

Mr. Browne is survived by his widow, Mrs. Flora D. Browne, two brothers in Kansas City, and two brothers and a sister in Pennsylvania. He was buried in the family plot at Huntingdon, Pa.

He was a member of the American Railway Engineering Association and the American Bridge and Building Association.

Mr. Browne was elected an Associate Member of the American Society of Civil Engineers on October 4th, 1893, and a Member on July 1st, 1909.

SAMUEL MERRILL GRAY, M. Am. Soc. C. E.*

Died November 5th, 1921.

Samuel Merrill Gray, the youngest son of David and Sarah M. Gray, was born at West Andover, Mass., on November 16th, 1842. His father was engaged in agricultural pursuits at that time, and the boy was brought up, as was customary with farmers' sons, working on the farm and attending the district school.

Later, his father moved from the farm to a part of the town near Phillips Academy, and it was then that the son began laying the foundation for his future, and decided to adopt the Profession of Civil Engineering for his life work. In this decision, he was encouraged by his teachers who recognized his ability and genius in mathematics and kindred subjects. While still in his teens, and striving to enter Harvard Scientific School, his health failed, compelling him to abandon, for the time being, the schoolroom for some outdoor occupation.

His instructors had been watching him for some time with considerable anxiety, and soon saw that if he continued his studies at the Academy, a general breakdown in his health was inevitable. Therefore, they advised him to give up the thought of entering college, and obtain his education in the field. He accepted their advice, gave up his studies early in the course at the Academy, and, in August, 1862, went to sea on a sailing vessel, returning early in the following year, greatly improved in health and fully determined that nothing should turn him from his purpose of becoming a civil engineer, even if he was unable to continue his preparatory course at the Academy.

At that time the engineering business was not brisk, and Mr. Gray experienced considerable difficulty in obtaining a position. Perseverance was one of his strong characteristics, and he finally secured a position in an engineering office at Woonsocket, R. I., where he was employed on what was then the New York and New England Air Line Railroad, now a part of the New York, New Haven, and Hartford Railway System. Later, he was engaged in locating

* Memoir prepared by George H. Leland, M. Am. Soc. C. E.

lines on the Connecticut Valley Railroad between New Haven and Hartford Conn., and on several other railway lines in the Middle West.

During these earlier years, while engaged in railroad building, he became interested in hydraulic and municipal work, devoting his spare time to these studies, particularly the designing and building of water-works systems and other municipal works.

Mr. Gray soon acquired a name for himself in his chosen profession, and was early recognized as a rising, ambitious, young engineer. He secured an appointment as an Assistant, and, later, became Chief Engineer of the water supply system of Hartford, retaining this position until the work was completed.

In 1869, Mr. Gray came to Providence, R. I., to accept the position of Assistant Engineer under the late J. Herbert Shedd, M. Am. Soc. C. E., on the water supply system of Providence. He was placed in charge of the construction of the Sockanosset and Hope Reservoirs, and other important parts of the System, remaining with Mr. Shedd until the works were completed.

On February 5th, 1877, he was elected City Engineer of Providence, a position which he held until May 5th, 1890. During his incumbency of this office, he was nominally in charge of all public works, water, sewers, streets, bridges, and harbors.

In 1884, the question of sewage disposal for the City of Providence was being agitated, and Mr. Gray with one of his assistants, the late Charles H. Swan, M. Am. Soc. C. E., was sent to Europe to make an exhaustive and comprehensive study of the various methods of sewage disposal then in use.

As the result of his observations and studies abroad, a report, with recommendations for intercepting sewers and sewage disposal, was submitted by him to the City authorities, and this report and recommendations were approved by Rudolph Hering, M. Am. Soc. C. E., and the late Joseph P. Davis, M. Am. Soc. C. E. The report was recognized at once as a valuable document on the subject of sewage disposal, and it became widely known in the United States and in Europe.

Early in 1890, certain changes in the management of the Public Works Department of the City of Providence made it necessary for Mr. Gray to resign his position as City Engineer, and he opened a private office for the practice of his profession. His first work of importance was the design of a sewerage system and a water-works plant for Chevy Chase, a suburb of Washington, D. C., which was followed by a sewerage system and sewage disposal plant for Chautauqua, N. Y.

His private practice soon increased and he was called to various parts of the country to advise regarding water and sewerage systems, and to act as expert in many damage suits, including the Kettle Brook cases, Blackstone Valley cases, "The Mill Owners *vs.* City of Worcester, Mass., for diverting the waters of Kettle Brook and its tributaries"; also, "The Mill Owners *vs.* City of Woonsocket, R. I., for diverting the waters of Crookfall Brook."

Among the places to which Mr. Gray was called to advise regarding water and sewerage systems are: Augusta and Brunswick, Me.; Meredith, N. H.; Bradford, Vt.; Natick, Springfield, and Worcester, Mass.; East Providence,

Bristol, Newport, and Westerly, R. I.; Binghamton, Syracuse, Cohoes, Troy, and Hornells, N. Y.; Lancaster, Philadelphia, and Meadville, Pa.; Wilmington, Del.; Paterson, N. J.; Albuquerque, N. Mex.; Helena, Mont.; Boise, Idaho; and several other places in the South and West, including Havana, Cuba, Toronto, Ont., Canada, and Monterey, Mexico.

He was associated with Mr. Hering on a sewage disposal plant for Baltimore, Md., and with Mr. Hering and the late Frederic P. Stearns, Past-President, Am. Soc. C. E., on a sanitary system for the District of Columbia.

In 1913, the question of an additional water supply arose for the City of Providence, R. I., and Mr. Gray was chosen as Chief Engineer to the Board of Water Commissioners. This position he retained until the preliminary investigations and surveys to determine the most desirable location for the new source of supply, and to secure the necessary legislation for the new project, were completed.

In 1915, Mr. Gray resigned the office of Chief Engineer for the Board of Water Commissioners and was appointed Chief Consulting Engineer, a position which he held almost to the time of his death.

Mr. Gray was a member of the Rhode Island State Board of Health for more than 30 years.

In early life, he became identified with the Christian church, and was a member of the Central Congregational Church of Providence at the time of his death.

Mr. Gray was systematic in his business methods, and required a strict accounting from all his assistants. Although firm, strict, and exacting in all his work, he was never harsh or disagreeable, but always cheerful and kind, and ready to help or assist his students in any way possible.

About 1904, his health became seriously impaired, and it was necessary for him to relinquish his personal practice for a few months in order to recuperate. During this illness, he suffered a great deal, but he bore up under the affliction with fortitude and good nature. Thinking that a change in his environment might prove beneficial, he disposed of his city residence in 1908, and removed to the country. Here, he devoted his spare time and energies to agricultural pursuits, and to building a country home for himself at Slocum, R. I. Naturally, he enjoyed country life.

He had made his early home in the vicinity of Hartford, Conn., where he was married to Miss Adelaide S. Gilbert who died in Providence in 1891.

Having been brought up under the shadow of the Andover Theological Seminary, Mr. Gray was a strict observer of the Sabbath. He would permit no work to be done on that day if it were possible to avoid it. It was the writer's pleasure to have been associated with Mr. Gray for the last thirty years as Principal Assistant, and whenever he was sent out on work, his instructions were, that when Saturday night came, if on the journey, to stop off, go to a hotel, and wait until Monday morning, and the bill would be honored.

Mr. Gray firmly believed in justice to all, and was often called on to arbitrate differences which arose between the party for whom the work was being done and the contractor doing the work. He was always glad and

willing to aid a contractor in any way compatible with his position as an engineer.

Mr. Gray was always kind and considerate with his students, and took a keen interest in their welfare. He leaves a host of friends who will mourn their loss.

Two children survive him: Mrs. Edith G. Wood, the wife of Dr. Harold B. Wood, Medical Officer of Dodge City, Kans., and Robert Gray, of Slocum, R. I.

Mr. Gray was elected a Member of the American Society of Civil Engineers on May 15th, 1872, and served as Vice-President of the Society in 1892.

PETER CONOVER HAINS, M. Am. Soc. C. E.*

Died November 7th, 1921.

Peter Conover Hains was born in Philadelphia, Pa., on July 6th, 1840. He was graduated from the U. S. Military Academy at West Point, N. Y., in June, 1861, and was appointed First Lieutenant in the 2d Artillery. In July, 1862, he was transferred to the Topographical Engineers, which Corps was consolidated with the Corps of Engineers in March, 1863.

Immediately on his graduation, Lieut. Hains entered active service in the field, and served throughout the Civil War, participating in twenty-three battles and actions. He was brevetted Captain for gallant and meritorious services at the Battle of Hanover Court House, on May 27th, 1862; Major for gallant and meritorious services during the siege of Vicksburg, Miss., on July 4th, 1863; and Lieutenant-Colonel for "gallant and meritorious services during the Rebellion", on March 13th, 1865.

After a year's service as Assistant Engineer on the improvement of the Des Moines and Rock Island Rapids of the Mississippi River, Capt. Hains was, in 1867, placed in command of the Engineer Depot and Post of Jefferson Barracks, Missouri. It was his first independent command. The qualities of thoroughness and sound judgment which had brought him distinction during the Civil War, here had a field of action in which the results could be attributed to him personally. The command of the Post carried with it the command of Company E, Battalion of Engineers. After more than three years of training by Capt. Hains, this company was sent to West Point, N. Y., where it came under the writer's command. Its instruction and discipline were of the highest order. It was a model of what an Engineer Company should be, reflecting the greatest credit on the officer who had trained it. The writer did not, at that time, know Capt. Hains personally, but he often thanked him mentally for the work which lightened his own labors so materially.

From 1870 to 1882, Maj. Hains was employed mainly on lighthouse duty, serving as Engineer of the Fifth Lighthouse District from November, 1870, to May, 1874; Engineer of the Sixth Lighthouse District from June, 1871, to May, 1874, and from July, 1879, to August, 1882; and Engineer Secretary of the Lighthouse Board from June, 1874, to July, 1879.

* Memoir prepared by O. H. Ernst, Maj.-Gen., U. S. A. (*Retired*), M. Am. Soc. C. E.

From 1882 to 1891, he was in charge of fortifications and of river and harbor works at Washington, D. C., and its vicinity. The most important work in this District was the reclamation of the Potomac Flats. Entering the up-stream limits of the City of Washington, with a width of less than 1 000 ft., the Potomac River spread out to a width of about 6 000 ft. opposite the middle and lower parts of the city. The channels for navigation were inadequate, and a large area of flats was uncovered at low tide. One of the main sewers of the city ran through these flats, in an open canal. At high tide, the sewage from this canal spread over the adjacent flats, turning them into a pestilential swamp. The remedy was to excavate channels of moderate width for navigation in the river, and use the excavated material for raising the flats. This work was inaugurated by Maj. Hains in 1882. In 1891, when he was called elsewhere, about three-quarters of the 12 000 000 cu. yd. estimated to be necessary had been placed on the flats. About 620 acres of malignant swamp had been transformed into healthful dry land, on which has since been constructed the beautiful Potomac Park. Although the work was finally completed by others, it is, more than is usual with public works, associated with the name of a single officer. The southerly end of Potomac Park has been named "Hains Point" by the War Department, and stands as a monument to his memory, unique and appropriate. A description of this work prepared by Maj. Hains has been published by the Society.*

From November, 1891, to November, 1894, he was in charge of fortifications and river and harbor works, with headquarters at Portland, Me., and from November, 1894, to May, 1895, was Engineer of the Third Lighthouse District, serving at the same time on various Boards of Engineers, of which the most important was the Board to report on the proposed deep-water harbor at San Pedro and Santa Monica Bays, California, in 1892.

From 1895 to 1900, Col. Hains was in charge of fortifications and river and harbor improvements in the District of which Baltimore, Md., was the headquarters, and served as Division Engineer of the Southeast Division, except while temporarily absent in Central America, and while in the field during the Spanish War.

He visited Central America from December, 1897, to March, 1898, as a member of the Commission created by Congress to examine the Nicaragua route for an Isthmian Canal. The construction of a canal on this route had been begun by an American corporation in 1889. This corporation had been driven into bankruptcy by the financial disturbances of 1893, and its plans and estimates had been severely criticized. The Commission of 1897 recommended some radical changes in the plans, especially in the estimates. Its report, however, was not completed when the revival of the Panama plan attracted the attention of Congress, and led to the creation, in 1899, of an Isthmian Canal Commission, to examine and report on all practicable routes for a canal across the Isthmus. Col. Hains was made a member of this Commission, but before it was created, he was called into the field for service in the Spanish War.

* *Transactions*, Am. Soc. C. E., Vol. XXXI (1894), p. 55.

He was appointed Brigadier General of Volunteers on May 27th, 1898, and assigned to the command of the 2d Brigade, 1st Division, 1st Army Corps, which he accompanied to Porto Rico, and which he commanded in the skirmishes at Guayama, on August 5th, and Las Palmas on August 8th, 1898. The peace protocol having been signed, he returned to the United States in September, and was mustered out of the Volunteer Service in November, 1898. For his conduct in this campaign, he was recommended by the Commander of the Expedition, the late Lieut.-Gen. Miles, for promotion to the grade of Major General, but the promotion was not made at that time.

The Isthmian Canal Commission of 1899 to 1904 made an examination of all the routes across the Isthmus, and an especially thorough one of the two principal routes, *via* Nicaragua and *via* Panama. The members of the Commission made many long journeys together, visiting Paris and the Kiel and Manchester Ship Canals, and passed many weeks in Central America. Their journeys brought them into close personal contact, giving them a more intimate knowledge of each other's character than many years of ordinary intercourse. Travel in Nicaragua especially was made under difficult circumstances. A large part of it was through a wilderness, in which every discomfort had to be endured, and, in the more civilized part, the public accommodations were rarely sufficient for so large a party. Every temptation was offered for the display of selfishness or bad temper, but on no occasion did Gen. Hains lose his equanimity. His sweetness of disposition and equability of temper will never be forgotten by his colleagues on those expeditions.

The Commission found that the best route for a canal was *via* Panama; it recommended the purchase of the French property and rights, on which it fixed a valuation of $40 000 000; and it submitted a plan for the canal, with estimates of cost, rejecting the sea-level plan and providing for locks. The property was purchased by the United States at the price mentioned, but it was not until 1904 that all legal and diplomatic formalities had been complied with, and the United States was free to begin the work of construction.

For construction purposes, the President decided to re-organize the Commission, and no member of the Engineer Corps of the Army was appointed. At the end of the year the Third Isthmian Canal Commission was organized on which were two officers of the Engineer Corps of the Army, of whom Gen. Hains was one. These officers found themselves in a minority of two on the subject of the type of canal. Shortly before the dismissal of the Second Commission, its Engineering Committee had submitted a report strongly favoring the sea-level type. The full Commission had not had time to take action on the report, but its contents were known to, and approved by, the President and the Secretary of War. Simultaneously with the appointment of the Third Commission, the President appointed a Consulting Board of thirteen distinguished engineers to determine the plan for the canal. This Board was unable to agree, but eight members, including all the foreigners, reported in favor of the sea-level type, whereas five favored the lock type.

The two reports of the Consulting Board came before the Isthmian Canal Commission for review and recommendation. The review of the subject by the Commission satisfied the President and the Secretary of War, and eventu-

ally Congress, that the proper type of canal for this Government to build was the lock type.

Gen. Hains had been promoted through the various grades in the Corps of Engineers until April 22d, 1903, when he was appointed Brigadier General in the line of the Army. He was retired from active service on July 6th, 1904, having reached the age of 64, the statutory limit. Under the provision of an Act of Congress, approved August 29th, 1916, he was promoted to the rank of Major General on the Retired List on November 2d, 1916.

When war with Germany was declared in 1917 he offered his services for any duty to which the Government might wish to assign him, and was placed in charge of the Engineering District of which Norfolk, Va., was the headquarters, where he served throughout the World War. He was probably the only officer of the Army who was on active duty throughout the Civil, Spanish, and World Wars.

Gen. Hains was married on November 17th, 1864, to Miss Virginia Pettis Jenkins, daughter of Rear-Admiral Thornton A. Jenkins, U. S. Navy. His widow and three sons survive him.

Those who knew him as the gallant soldier, the skillful engineer, the accomplished gentleman, and the loyal friend, can understand what a stunning blow his death must be to those who knew him also as the tender and devoted protector.

Gen. Hains was elected a Member of the American Society of Civil Engineers on April 2d, 1890.

HOWARD CARLETON HOLMES, M. Am. Soc. C. E.*

Died October 30th, 1921.

Howard Carleton Holmes was the only son of Cornelius and Maria Folger Holmes. He was born on the Island of Nantucket, Massachusetts, on June 10th, 1854, and when five years of age went with his parents to San Francisco, Cal.

After receiving his education in the public schools of San Francisco, he entered the City Engineer's Office of Oakland, Cal. Later, he began as a Surveyor and became identified with a number of leading engineers. Mr. Holmes was only 19 years old when he made the topographic surveys and maps necessary for the development of Lake Chabot, the principal source of water supply of the City of Oakland. At 21, he passed an examination for appointment as United States Deputy Surveyor, and soon afterward became Assistant Engineer of the Board of State Harbor Commissioners, leaving this position to design and build the Alameda Mole and Depot for the South Pacific Coast Railway Company.

Mr. Holmes then directed his attention to street railway construction and, in 1887-88, designed and built the Powell Street Cable Railway, then known as the Ferries and Cliff House Railroad. During the next few years, he

* Memoir prepared by James J. Walsh, Assoc. M. Am. Soc. C. E.

designed and built the cable railroads at Portland, Ore., at Spokane, Wash., and the Madison Street Railway in Seattle, Wash. Returning to San Francisco, he designed and constructed the Sacramento Street Branch of the Ferries and Cliff House Railroad and the lower end of the California Street Railroad, and extended the Union Street Cable Railroad from Fillmore Street to the Presidio. Later, he secured the contract for the design and construction of the original electric railway at Stockton, Cal.

In 1892, Mr. Holmes was appointed Chief Engineer of the Board of State Harbor Commissioners and many wharf structures along the water-front of San Francisco and also the Union Ferry Building at the foot of Market Street, the foundation of which was a notable piece of engineering work, were built under his direction. He also designed the passenger and freight ferry slips of all the railroads on San Francisco Bay, with the exception of the Southern Pacific Company. Mr. Holmes was the designer and inventor of many improvements and innovations in harbor construction.

In 1901, he resigned his position with the State Harbor Board to become Chief Engineer of the San Francisco Dry Dock Company to design and construct a 750-ft. granite and concrete graving dock at Hunter's Point. In 1916, as Consulting Engineer for the Bethlehem Shipbuilding Company, he designed and supervised the construction of a 1 025-ft. concrete and granite graving dock also located at Hunter's Point, San Francisco.

From 1902 to 1910, he was retained as Chief Engineer of San Francisco-Oakland Terminal Railways, and designed and supervised the construction of ferry slips, terminal buildings, wharves and extensive double-track trestle. From 1905 to 1910, he was also retained as Consulting Engineer during the construction period of the Western Pacific Railroad, and designed and supervised the Oakland Freight and Passenger Terminal and the San Francisco Freight Terminals of that Company. Mr. Holmes was also engaged by the Panama-Pacific International Exposition from 1913 to 1915 as Consulting Engineer. In addition, at different periods during the last decade, Mr. Holmes was retained in the capacity of Consulting Engineer for the Esquimalt Shipbuilding and Drydock Company, Moore Shipbuilding Company, Richmond Belt Railway, South San Francisco Land and Improvement Company, Northwestern Pacific Railway Company, and others.

His judgment and intelligence gave great weight to his opinions in all matters pertaining to engineering work. Mr. Holmes was eminently successful in his chosen profession; his business dealings were characterized by the utmost fairness to his clients and contractors alike, and a host of friends along the entire Pacific Coast mourn his loss. His death, which occurred on October 30th, 1921, resulted from a stroke of paralysis after an illness lasting several weeks.

In 1883, Mr. Holmes was married to Miss Josephine Bauer who survives him.

He was a member of the Engineers' Club, the California Academy of Science, the Seismological Society of America, and a prominent Mason and Knight Templar. Mr. Holmes was also prominent in the club life of San

Francisco, having been a member of the Pacific Union, Bohemian and San Francisco Golf and Country Clubs.

Mr. Holmes was elected a Member of the American Society of Civil Engineers on November 4th, 1903. He was also a member of the San Francisco Section of the Society.

WARREN CHAMBERLAIN TUDBURY, M. Am. Soc. C. E.*

Died May 18th, 1921.

Warren Chamberlain Tudbury, the son of the late John Thomas and Sarah Lizzie (Tibbets) Tudbury, was born in Salem, Mass., on November 14th, 1877.

In 1900, he was graduated from the Massachusetts Institute of Technology with the degree of S. B. in Civil Engineering, and immediately obtained a position with the New York Central and Hudson River Railroad Company. For the next eleven years, with the exception of two brief periods, he remained with this Company and had much to do with the design and execution of important betterments of its lines, including the elimination of grade-crossings, grade revisions, and marine terminals.

From March, 1911, to February, 1912, Mr. Tudbury held the position of Assistant Engineer on Railroad Valuation in the Bureau of Engineering Statistics and, under the direction of George F. Swain, Past-President, Am. Soc. C. E., had charge of bridge calculations and compilations.

From February, 1912, to September, 1913, he was Designing Engineer on important grade-crossing elimination work under the direction of C. M. Spofford, M. Am. Soc. C. E.

In 1914, Mr. Tudbury went to Los Angeles, Cal., to make his home. He there opened an office and carried on a successful engineering practice until late in 1916, when he entered the Government Service in the Bureau of Yards and Docks, at Washington, D. C. His experience in railroad engineering was of great benefit in connection with many of the large projects carried out by the Navy Department during the World War.

In June, 1918, he was transferred to the Engineering Force of the Navy Yard, at Mare Island, Cal., with the title of Expert Aide. Shortly after his transfer to Mare Island, his health began to fail. Notwithstanding his illness, however, he bravely and without complaint gave the Government faithful and valuable service until within a few weeks of his death, which occurred at his home in Berkeley, Cal., on May 18th, 1921.

He is survived by his widow, who, before her marriage in 1914, was Ethel Putnam Wheeler, of Salem, Mass., by a daughter, Patricia Breed Tudbury, and by his mother and sister.

On his mother's side, Mr. Tudbury was descended from some of the earliest and most prominent New England families, families which were identified with the history of the Colonies, the Revolution, and the War of 1812. It is, therefore, only natural, perhaps, that he should have had so great an interest in the early history of the Colonies and in the genealogy of the

* Memoir prepared by A. W. Earl, Assoc. M. Am. Soc. C. E.

prominent Colonial families. He collected and arranged a vast amount of genealogical data which he left to the Society of the Sons of the Revolution in Los Angeles. He also left, for future publication, a manuscript giving an account of the adventures of the privateer, *The Grand Turk,* which sailed from Salem under the command of his great-grandfather, Holten Johnson Breed, during the War of 1812. At the time of his death, he was working on a book entitled "The History of the Copp Family."

The early history of the United States was the most important interest of his leisure hours, but he was also a great lover of birds and a student of their ways. He delighted in photographing them in the various stages of their development, and some of his photographs have been published.

Mr. Tudbury belonged to the Society of Colonial Wars, the Society of the Sons of the Revolution, the Society of the War of 1812, the California Genealogical Society, the American Philatelist Society, and the American Ornithologists' Union.

His great friendliness and gentle ways made for him many friends among those with whom he came in contact, and he will be greatly missed by those that were so fortunate as to know him.

Mr. Tudbury was elected an Associate Member of the American Society of Civil Engineers on June 1st, 1909, and a Member on March 12th, 1918.

GISLI GUDMUNDSSON, Assoc. M. Am. Soc. C. E.*

Died July 19th, 1921.

Gisli Gudmundsson was born at Bordeyre, Iceland, on March 31st, 1862. He attended the Technical Institute, Copenhagen, from 1883 to 1885, and received the degree of Civil Engineer from the Teknisk Loereanstalt, at Trondhjem, Norway, in 1889. At this time, he entered the service of the Norwegian Government, and was engaged in highway construction for two years, having been employed a part of that time on the "Kaiser Wilhelm Way," and on harbor work.

In 1893, Mr. Gudmundsson resigned from this position and came to the United States, settling in Pittsburgh, Pa., which city was his home until his death. For the next three years, he was employed as Draftsman and Estimator with the Shiffler and Keystone Bridge Companies, with the Lake Erie and Ohio River Canal Commission, and with the Pennsylvania Lines West of Pittsburgh. For a short time during this period, he also served as an Engineer on the location of thirty miles of railroad in Guatemala.

From 1896 to 1898, Mr. Gudmundsson was with the late Hermann Laub, Assoc. M. Am. Soc. C. E., on bridge and building design and erection, and, in 1898, he had charge of construction with the Pittsburgh Plate Glass Company. In 1899, he again entered the employ of Mr. Laub, this time as his Principal Assistant. In this position, Mr. Gudmundsson had charge of the design and erection of the Allegheny River Bridges at New Kensington and Highland Park, Pittsburgh, and numerous other bridges and buildings.

* Memoir prepared by Vernon R. Covell, M. Am. Soc. C. E.

In 1903, he entered into business for himself and was engaged in a general civil engineering practice until his death. During this time, he designed and built the bridges for the Indianapolis and Louisville Traction Railway Company; the power house and car barn for the Southern Cambria Railway Company, at Mineral Point; the Woodvale Avenue Viaduct, at Johnstown; the South Fork Bridge, at South Fork; and the highway bridge over the Pennsylvania Railroad at Ebensburg, Pa. He also designed and had charge of the alterations and construction of the new plants of the Mesta Machine Company at West Homestead; the Kittaning Brick and Fire Clay Company, at Kittaning, and the Lockhart Iron and Steel Company, at Pittsburgh, Pa., and made examinations and detailed reports on several bridges over the Beaver River for Beaver County, Pennsylvania. From 1911 to 1917, he acted as Consulting Engineer for the Pittsburgh and Butler Railway Company, during which time he made detailed reports on all the bridges on the line, and designed and built the bridges from Slippery Rock to Grove City, Pa.

At different intervals, he co-operated with the Engineer's Office of Allegheny County, at Pittsburgh, in the design of the Sewickley Bridge over the Ohio River, and in remodeling the 7th and 30th Street Bridges over the Allegheny River, and the 3d and 5th Avenue Bridges over the Youghiogheny River, at McKeesport, Pa.

Mr. Gudmundsson was a careful student of events in the United States and abroad, and took a deep interest in all civic and philanthropic matters. He was of a genial disposition and had many warm personal friends.

He was an active member of the Engineers' Society of Western Pennsylvania and of the Lincoln Club of Pittsburgh. He had no relatives in America.

Mr. Gudmundsson was elected an Associate Member of the American Society of Civil Engineers, on January 3d, 1900.

ARTHUR JOHN HART, Assoc. M. Am. Soc. C. E.*

Died June 26th, 1920.

Arthur John Hart, the youngest son of the late Sidney John Hart, was born at Chatham, Kent, England, on December 15th, 1887. His early life was passed in England where he received his education.

In January, 1905, Mr. Hart secured a position as Pupil with the City Engineer of Rochester, England. He quickly advanced to the rank of Assistant on the construction of a concrete reservoir and six miles of electric tramway, and on the re-survey of that city. In September, 1908, he entered the employ of the Indented Bar and Concrete Engineering Company, Limited, in London, England, and spent 3½ years as Assistant on the design and supervision of many large reinforced concrete works, at H. M. Dockyard, Rosyth; the military barracks, at Abbasia, Cairo, Egypt; H. M. New Stationery Office,

* Memoir prepared by Myles J. Dunphy, Esq., Sydney, N. S. W., Australia.

London; the new Royal Automobile Club, London, and many other similar works.

In May, 1912, Mr. Hart was appointed Chief Representative Engineer in Australia for the Indented Bar and Concrete Engineering Company, Limited, and left England to take up his new position in Sydney. In a short time, he began the practice of his profession as Consulting Engineer and Chief Representative Engineer for the Indented Bar Company. His chief interest lay in reinforced concrete and his progressive methods and ideas, together with his comprehensive knowledge of this building material, quickly placed him at the forefront, as the most active advocate for this method of construction in Australia.

From 1912 to 1920, Mr. Hart regulated and controlled a constantly expanding practice and kindred businesses. His practical criticism and series of lectures before the Institute of Civil Engineers in Sydney were responsible to a great extent for the revision of the municipal by-laws of the City of Sydney relating to construction in reinforced concrete and structural steel. During these eight years, the work under Mr. Hart's charge must have aggregated in value several millions of pounds sterling. Everywhere in Sydney, and throughout the Commonwealth of Australia, his works stand as eloquent and striking testimony to his greatness as a designer and constructor, and as continual reminders to his friends.

Bearing on the earlier period of Mr. Hart's life there is a dearth of information, but from what his friends in Australia know of his fine personality, capacity for noting detail, together with the end in view, and his hunger for further information, it is not surprising to learn that his interest in life was by no means centered in the practice of his profession alone.

He was a member of the Automobile Club of Australia and of the Royal Sydney Yacht Squadron; his car and his yacht *Lowanna,* his hockey, tennis, and other outdoor interests, he enjoyed with wholehearted vigor. For a time, he was Secretary of the Athletic Rifle Club of Sydney. Offering his services to his country early in the World War, and having been rejected for the physical defect which eventually proved fatal, he gave a large part of his time to war service work.

It has been said, and there is some truth in the saying, that an engineer is almost wholly devoid of the artistic perception, but Mr. Hart at least was a master constructor, an expert administrator, and a capable art critic.

Mr. Hart extended his help to the young craftsmen and professional cadets at the Sydney Technical College in a free and practical manner; for some years, and up to the time of his death, the prize list never failed of his contribution, and he esteemed it an honor to be allowed to set an examination paper annually in the subject nearest his chosen profession.

He was married in 1916 to Miss Gwendolyn Wood, the youngest daughter of the late Quayle Wood, of Brundah Station, and Mrs. Wood, of Kirribilli Point, Sydney, who, with their two baby daughters, survives him.

Mr. Hart was elected an Associate Member of the American Society of Civil Engineers on October 14th, 1919.

CHARLES WHITING BRADLEY, Affiliate, Am. Soc. C. E.*

DIED JANUARY 14TH, 1920.

Charles Whiting Bradley was born at Newtown, Conn., on September 13th, 1836.

He entered the service of the Erie Railroad at Nanuet, N. Y., in November, 1852, as Telegraph Operator, and remained with that Company until 1862. From 1862 to 1868, Mr. Bradley held several positions with the Atlantic and Great Western Railroad Company, rising to that of Division Superintendent.

From 1868 to 1870, he served as Superintendent of the Cincinnati, Chicago, and Louisville Railroad, and from 1870 to 1872, he was engaged as Superintendent of the Niles and New Lisbon Railroad. In 1872, he returned to the Atlantic and Great Western Railroad as Division Superintendent, which position he held until 1873. From 1873 to 1878, Mr. Bradley was employed as Division Superintendent of the Wabash, St. Louis, and Pacific Railway, and, from 1878 to 1880, he served as General Western Traffic Manager of the same road.

In 1880 and 1881, he was Division Superintendent of the Denver and Rio Grande Railroad, and from 1881 to 1882 he was Superintendent of the Cincinnati and Northern Railroad.

During 1882 and 1883 he held the position of Assistant Superintendent of Construction with the New York, West Shore, and Buffalo Railway Company, and from 1883 to 1885, he was Division Superintendent of that road. From 1885 to June 1st, 1898, Mr. Bradley was General Superintendent of the West Shore Railroad, and, afterward, was connected with the Walkill Valley Railroad, and also served as Manager of the Western New York Car Service Association, at Buffalo, N. Y.

Mr. Bradley then entered the service of the Chesapeake and Ohio System as Superintendent of the Telegraph Department, which position he held until his death on January 14th, 1920, at Nyack, N. Y. For ten years before his death he had made his home in Richmond, Va., and was on a visit to his nephew at Nyack where he was taken ill and died.

Mr. Bradley was of modest disposition, kind and gentle, and had many friends. He was married in 1857 to Miss Annie E. Tallman, of Nanuet, N. Y., who survives him.

He was widely known among railroad men and had been for many years a prominent member of the American Railway Engineering Association, having served as a delegate to the International Railway Conference in London, England, in 1895. He also attended a similar convention in Berne, Switzerland, in 1910. At the time of his death, Mr. Bradley was a member and President of the Old-Time Telegraphers' Association of the United States. He was also a member of the Chesapeake and Ohio Veteran Employees' Association and the Westmoreland Club of Richmond, Va.

Mr. Bradley was elected an Affiliate of the American Society of Civil Engineers on June 19th, 1891.

* Memoir compiled by the Secretary from information on file at the Headquarters of the Society.

GEORGE LORD BURROWS, Affiliate, Am. Soc. C. E.*

Died November 9th, 1921.

George Lord Burrows was born in Albion, N. Y., on August 30th, 1836. He received his education at the Albion Academy and Fort Edward Collegiate Institute, where he studied engineering.

After leaving college, he worked with the Engineering Corps on the enlargement of the Erie Canal and afterward with the Bank of Albion, where he gained the knowledge of banking which he used to such good advantage later.

In 1862, Mr. Burrows went to Saginaw, Mich., where his successful career has been closely connected with the history of the Saginaw Valley.

In May, 1862, he established the private bank of George L. Burrows and Company in Saginaw. This bank was his first business enterprise in that city, and was conducted by him and his associates until 1915, when it was sold to the Bank of Saginaw.

Mr. Burrows saw the possibilities of the pine lands in Michigan, and early became prominently identified with the lumber interests of Central Michigan, in the development of which he became a powerful influence.

About the same time, he became interested in the construction of the first street car line in Saginaw. He served as Treasurer of the Company which built the line, and also of the Company which built the Mackinaw Street Bridge.

In 1885, Mr. Burrows was elected President of the Niagara Falls International Bridge Company. His father, Lorenzo Burrows, had been one of the builders of the Suspension Bridge across the Niagara River near the Falls, and Mr. Burrows succeeded his father as head of the organization controlling the bridge. He held this position at the time of his death. In 1897, during his incumbency of this office, the Suspension Bridge was changed to a steel arch bridge.

As a lumberman, banker, and engineer, Mr. Burrows was closely identified with many of the early enterprises of Saginaw, and did much toward the development of the city, to which he gave freely of his services in its public works. He served as Chief of the Volunteer Fire Department and in this capacity superintended the construction of the West Side Water-Works. He also acted as Supervising Engineer on the construction of the Saginaw County Court House, and was for many years a member of the School Board of the West Side Union School District.

He was regarded by his friends and acquaintances as a man of unusual intelligence and integrity, well informed, and an excellent financier. He gave generously of his wealth, both to individuals and organizations, and always insisted that nothing be said concerning his charities.

The following high tribute has been paid to Mr. Burrows:

* Memoir compiled by the Secretary from information on file at the Headquarters of the Society.

"It may be said of him without reserve what cannot be said of every man who has acquired large means, his best friends are those who know him best and his personal integrity is without stain."

Mr. Burrows was married on June 25th, 1863, in Buffalo, N. Y., to Miss Julia S. Hotchkiss, who died in Saginaw on October 14th, 1883. He is survived by one son and five daughters.

He was a member of the Engineers' Club, the Union League Club, and the Bankers' Club, all of New York City, and of the Biscayne Bay Yacht Club, of Miami, Fla. He also belonged to the Masonic Order.

Mr. Burrows was elected an Affiliate of the American Society of Civil Engineers on February 3d, 1886.

CALVIN TOMKINS, Affiliate, Am. Soc. C. E.*

Died March 13th, 1921.

Calvin Tomkins, the son of Walter and Emma Augusta (Baldwin) Tomkins, was born in East Orange, N. J., on January 26th, 1858.

He was graduated with honor from Cornell University, in the class of 1879, with the degree of A. B. Within a few years thereafter he was elected President of the New York Association of Cornell University, and throughout his life was a leader among Cornell Alumni and active in support of the University.

Early becoming one of a group of art workers and amateurs, Mr. Tomkins was associated with leading artists of New York City in the movement from which later grew the Fine Arts Federation, with its associated societies. He became President of one of the more prominent of these societies, the Municipal Art Society, and was also one of the founders of the National Arts Club.

In 1887, he assisted in the organization of the Reform Club, and was successively prominent in its Tariff Reform, Sound Currency, and City Development Committees. He also served for years as President of the Club.

Having been active in the re-election of President Cleveland, whose confidence he enjoyed, he was a leader in the Gold Democratic Movement in opposition to Free Silver, and a candidate for Congress in the Palmer and Buckner Campaign.

In 1884, he succeeded his grandfather, Calvin Tomkins, as a Director in one of a group of business concerns which since early in the last century had been developed by members of his family, and the death of his father in 1896 left him mainly responsible for the conduct of manufacturing and mining plants at Tomkins Cove and Rondout, N. Y., Newark, N. J., and in Nova Scotia and New Brunswick, Canada.

Always a student of the problems growing therefrom, Mr. Tomkins was early recognized as an expert by the New York Chamber of Commerce, Board of Trade and Transportation, Maritime Association, and other commercial bodies of New York City, in which, before 1910, he had become prominent in helpful criticism of subway development, and as an adviser of Governor

* Memoir prepared by B. F. Cresson, Jr., M. Am. Soc. C. E.

Hughes in the reform by which the old commission was displaced and plans progressed for city ownership and control.

Having been active and influential in securing the passage of the Constitutional Amendment exempting self-sustaining dock and subway bonds from the debt limit of New York City, and a leading advocate of the election of Mayor Gaynor, he was urged by the Mayor, on his election, to share the responsibility of the Administration, and notwithstanding business obligations which he could not transfer, he accepted the office of Commissioner of Docks on January 1st, 1910, an appointment which gave great satisfaction to the commercial interests of the city.

Mr. Tomkins commenced and developed vigorous and tactful propaganda for adequate development of the Port of New York as a unit, irrespective of city and State boundaries. This propaganda has gradually enlisted public support, until the essential of the plan urged by Mr. Tomkins is the groundwork of the world port to which the States of New York and New Jersey are now practically committed.

Mr. Tomkins was not in sympathy with the policy of executing long-term leases of docks and piers, and most of the leases which fell due during his administration were held over on permits for one or two years, in an effort to secure control of considerable stretches of water-front and institute a comprehensive physical plan.

He sought information as to port administration, organization, and equipment, not only at American, but also at European, ports, and was a strong advocate of public control of harbor facilities, such control to extend at least as far as public ownership.

He was insistent in his demand that there must be a railroad connection between the west side and the east side of the port for the movement of railroad freight, by tunnel or bridge. Plans were developed by him for bringing all the railroads into Manhattan to joint railroad terminals; and legislation secured to make possible the construction of a marginal railroad in Brooklyn, and in developing plans for many sections of the port, took into consideration the needs and possibilities of New Jersey as well as New York.

In 1911, Mr. Tomkins called together representatives of the Port Authorities in the United States, and at a meeting held in the Chamber of Commerce of the State of New York, he organized the National Association of Port Authorities, of which he was elected President, the Association later changing its name to the American Association of Port Authorities, in order to include the port authorities of Canada.

The Material Handling Machinery Manufacturers Association, an organization made up of the manufacturers of freight-handling machinery, organized primarily at the request of the United States Shipping Board early in the World War, chose Mr. Tomkins as its President.

He was called on by the United States Government during the World War and served as a member of the Board devoted to the operation of inland waterways of the country, among the activities of which was included the operation of the New York State Barge Canal.

His co-operation and advice were sought by the authorities of many of the ports of the country, and his judgment was held in high esteem in harbor, terminal, and transportation matters. Acting on his advice, the City of Wilmington, Del., acquired a large tract of property and has commenced the construction of a municipal terminal.

Mr. Tomkins was a member of the Commission appointed in 1911 by the Governor of New York State to co-operate with a similar Commission appointed by the Governor of New Jersey to investigate conditions at the Port of New York and to make recommendations.

He was a Delegate to the National Democratic Convention in San Francisco, Cal., in 1920. He was taken seriously ill on the trip, and although he partly recovered, he never quite regained his full health, and died on March 13th, 1921.

He was married on December 4th, 1889, to Kitty Neilly, of Stony Point, N. Y., who survives him.

His death is a severe loss to the city in which he lived, to the transportation interests, and to those who have the responsibility of creating and improving the port terminals of the United States.

Mr. Tomkins was elected an Affiliate of the American Society of Civil Engineers on January 6th, 1886.

JAMES FRANCIS WRENN, Affiliate, Am. Soc. C. E.*

Died November 2d, 1921.

James Francis Wrenn, the son of James and Sarah Wrenn, was born at Lynchburg, Va., on May 30th, 1867. He received his education at the public schools of his native town, and was graduated from the Virginia Military Institute.

Mr. Wrenn's first experience in engineering work began at the early age of fifteen. Owing to ill health, he was compelled to discontinue his studies temporarily, and on February 2d, 1882, went to Alabama with an uncle who was a prominent railroad contractor. At that time his uncle had a contract for the construction of 20 miles of the Georgia Pacific Railroad, between Atlanta, Ga., and Birmingham, Ala. The boy was employed on this work until September, 1882, when he returned to Lynchburg to resume his studies. In September, 1887, he entered the Virginia Military Academy. During his summer vacations, Mr. Wrenn worked for his uncle and for his grandfather, who was also a contractor, on their different construction contracts.

In 1890, immediately after his graduation from the Institute, he was appointed Assistant Superintendent and Engineer of Construction on a contract for double-tracking the Norfolk and Western Railroad, west of Salem, Va.

From 1892 to August, 1893, Mr. Wrenn was engaged as a Contractor, by the Roanoke Development Company, to build a cantilever bridge across the Roanoke River, at Roanoke, Va., and to construct the first improved street for the City of Roanoke.

* Memoir prepared by S. A. Lovette, Esq., Roanoke, Va.

From August, 1893, to September, 1894, he constructed five miles of new grade for the Atlantic Coast Line Railroad, on the Augusta Cut-off around Petersburg, Va., from Dunlap to Rheme Stations.

From March, 1895, to April, 1897, Mr. Wrenn was engaged in the construction of a canal and dam for developing a new water power for the Roanoke Rapids Power Company, at Roanoke Rapids, N. C., and from April, 1897, to March, 1898, he constructed ten miles of the Mobile, Jackson, and Kansas City Railroad, between Mobile, Ala., and Hattiesburg, Miss.

From March to July, 1898, he was employed in lengthening the side-tracks on the Mobile Division, at Flemington, Ala., for the Louisville and Nashville Railroad, and from July to December, 1898, in constructing two miles of new grade for the Seaboard Air Line, between Lawrenceville and Logansville in Georgia, thirty miles east of Atlanta.

In 1899, Mr. Wrenn was appointed General Superintendent of Construction for Samuel Walton, Contractor, and was engaged in constructing for the Norfolk and Western Railroad a low-grade line cut-off, near Radford, Va., which included a tunnel through a spur of the Blue Ridge Mountains. He was also engaged on the construction of the last ten miles for the Virginian and Southwestern Railroad, from Elizabethton to Mountain City, in Tennessee.

In 1900, he was employed on the subway construction in New York City, and, in 1901, as a Contractor on the construction of a soft tunnel for the Government, in Washington, D. C., during which a large intercepting sewer was laid 60 ft. under the surface of M Street, S. E. In 1902, he constructed an 18-mile electric line from Danbury, Conn., to Golden Bridge, on the Harlem Division of the New York Central Railroad, in New York State, and, in 1903 he built 20 miles of electric line from Rutland to Fair Haven, in Vermont.

In 1904, Mr. Wrenn was made General Superintendent for a contracting company, in which capacity he constructed a section of the Wabash Railroad into Pittsburgh, Pa. In 1905, he became General Superintendent for the William J. Oliver Company, of Knoxville, Tenn., and was engaged on the work of double-tracking the "Big Four" Railroad between Cincinnati, Ohio, and Indianapolis, Ind. In July of that year, he was transferred to Norfolk, Va., to take charge of the construction of the first 100 miles of the Tide Water Railroad (now the Virginian Railway), from Norfolk, Va., west.

In July, 1906, he was sent to New Orleans, La., in charge of the construction of the first 100 miles of the New Orleans and Great Northern Railroad, from Slidel, La., toward Jackson, Miss. In 1907, Mr. Wrenn was appointed General Superintendent for a Philadelphia company, and had charge of the construction of a low-grade line of 25 miles for the Erie Railroad, in New York State, from Hornellsville on the Buffalo Division, to Cuba, on the Chicago Division. This cut-off was constructed for the purpose of eliminating heavy grade on the Chicago Division, and was an extremely difficult piece of work.

During 1908 and 1909, he held the position of General Superintendent for a New York contracting company and was engaged in building improved highways in New York State, west of Albany, at Canajoharie, Fonda, Glovers-

ville, and Northville. This work was done under the first $50 000 000 appropriation made by the Public Works Department of New York State. In 1910, he was transferred and made General Manager of two sections of the New York State Barge Canal on the Champlain Division, between Waterford and Stillwater, N. Y.

In 1911, Mr. Wrenn formed a co-partnership with Mr. F. G. McGuire of Norfolk, Va., which was incorporated as the McGuire Construction Company, and served as its Vice-President and General Manager until March 31st, 1916. During this period this Company constructed improved streets for the Cities of Fayetteville, Newbern, Wilmington, and Greensboro, N. C., nine miles of concrete highway in Prince George County, for the State of Maryland; laid asphalt paving for the Towns of Easton and Salisbury, Md.; and constructed asphalt streets for the City of Danville, Va.

In 1916, Mr. Wrenn bought out Mr. McGuire's interest, and continued to operate the Company as President and Manager. During the same year, he constructed asphalt streets for the City of Suffolk, Va.

During the World War, he gave his services to the Government, and afterward was engaged as Constructing Engineer for the R. D. Lassiter Company, of Norfolk, Va.

Mr. Wrenn was very popular in the business as well as the social circles of Norfolk, Va. He is survived by one daughter, Virginia, ten years of age.

Mr. Wrenn was elected an Affiliate of the American Society of Civil Engineers on September 6th, 1905.

PAPERS IN THIS NUMBER

"SOME NOTES ON THE LOCATION AND CONSTRUCTION OF MOVABLE DAMS ON THE OHIO RIVER, WITH PARTICULAR REFERENCE TO OHIO RIVER DAM NO. 18." WILLIAM M HALL.

"DESIGN OF AERATION UNITS AND SEDIMENTATION TANKS FOR THE ACTIVATED SLUDGE SEWAGE DISPOSAL PLANT AT MILWAUKEE, WISCONSIN." DARWIN W. TOWNSEND.

CURRENT PAPERS AND DISCUSSIONS

PROCEEDINGS

OF THE

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OF

CIVIL ENGINEERS

VOL. XLVIII—No. 2

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February, 1922

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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XLVIII—No. 2.

FEBRUARY, 1922

Edited by the Secretary, under the direction of the Committee on Publications.

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NEW YORK 1922

The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

HEADQUARTERS OF THE SOCIETY—33 WEST THIRTY-NINTH STREET, NEW YORK.

TELEPHONE NUMBER........................7100 Longacre.
CABLE ADDRESS........................"Ceas, New York."

Vol. XLVIII. FEBRUARY, 1922. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

SOCIETY AFFAIRS

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MINUTES OF MEETINGS

OF THE SOCIETY

REPORT IN FULL OF THE SIXTY-NINTH ANNUAL MEETING, JANUARY 18TH, 19TH, AND 20TH, 1922.

Wednesday, January 18th, 1922 (10 A. M.).—The Sixty-ninth Annual Meeting was called to order in the Auditorium of the Engineering Societies Building, 33 West 39th Street, New York City; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present also about 560 members.

The President.—The meeting is called to order. I announce the appointment of the following as Tellers to canvass the ballot for the Annual Election: W. G. Grove, *Chairman;* C. S. Bilyeu, A. W. Carpenter, Ralph H. Chambers, C. E. Conover, R. de Charms, Myron E. Fuller, R. R. Graham, H. P. Hammond, George Perrine, F. W. Perry, D. H. Sawyer, and George L. Sawyer.

The Tellers are counting the ballots and their report will be presented before the close of the meeting.

The Acting Secretary will now read the report of the Board of Direction.

The Acting Secretary.—Mr. President, the report of the Board of Direction has been printed and distributed. I take it that it is not necessary to read it in full.

(The Secretary presented the report of the Board of Direction.*)

The President.—Gentlemen, you have heard the report of the Board of Direction; what is your pleasure?

F. S. Curtis, Past-President, Am. Soc. C. E.—I move the report be accepted.

(Motion duly seconded.)

The President.—It is moved and seconded that the report be accepted. All those in favor will give assent by saying "aye"; contrary, "no". The motion is carried.

The next business is the report of the Acting Secretary.

The Acting Secretary.—Mr. President, this report appears in the same pamphlet with the report of the Board of Direction. It is merely a detailed statement of receipts and expenditures during the year.

(The Acting Secretary read his report.†)

In addition to what is shown in the report, several requests have been received that the manner in which the Society's money is received and expended be indicated by percentages, and that has been tabulated as follows:

Under receipts: Entrance fees, 7.03%; dues, 74%; sale of publications, 1.8%; sale of badges and certificates, 1.9%; rent from Fifty-seventh Street property, 8.7%; Annual Meeting, 0.6%; interest, 0.6%; miscellaneous, 5.1%.

Under expenditures: Salaries of officers, 3.9%; clerical help, 15.3%; publications, 27.7%; postage, 5.4%; general printing, 4.0%; furniture and office supplies, 2.3%; badges and certificates, 1.9%; rent, 4.2%; Library and Reading Room, 3.7%; meetings, 0.8%; mileage of Directors, 4.8%; work of committees, 5.7%; Annual Meeting and Annual Convention, 2.1%; interest on mortgage on Fifty-seventh Street property, 3.8%; current business, 1.4%; Employment Bureau, 1.1%; retirement allowance, 2.9%; and miscellaneous items, 9.0%.

The President.—Gentlemen, you have heard the report of the Acting Secretary, what action do you wish to take?

C. W. Hudson, M. Am. Soc. C. E.—I move it be accepted.

(Motion duly seconded.)

The President.—All those in favor of the motion will give assent by saying "aye"; contrary, "no". The motion is carried.

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* See p. 183.

† See p. 190.

The next is the Treasurer's report.

(The Treasurer presented his report.*)

The President.—Gentlemen, you have heard the report of the Treasurer, what is your pleasure?

(It was moved and seconded that the report be received.)

The President.—It is moved and seconded that the Treasurer's report be received. All those in favor of the motion will give assent by saying, "aye"; contrary, "no". The motion is carried.

Gentlemen, it might be in order at this time to state some of the actions taken by the Board of Direction at its meetings on January 16th and 17th, 1922. The President was authorized to appoint a committee of seven to make a final report within the year on Fire Protection and Fire Prevention. This Committee is to consider the report made to the National Fire Protection Association on November 7th, 1921, on the fire hazards of docks, piers, and wharves, in co-operation with the committees of other associations, to analyze the regulations proposed in the report, their general adoption, and future expenses.

The question of the appointment of a Committee on Stresses for Structural Steel was referred to the Research Committee. It was decided to continue the Committee on Licensing of Engineers until the next general meeting of the Board of Direction to be held probably in March or April, 1922.

A new method of computation was adopted, which simplifies the manner in which applications for membership are now acted on, and which will enable the Membership Committee, it is believed, to classify them much more intelligently. The Committee considering the possibility of creating a Benevolent Fund was continued, and further report will be made at a later meeting of the Board of Direction.

A report from the Committee of the Board on the Promotion of the Technical Interests and Activities of the Society was received and adopted. This report covers an extensive program for extending the activities of the Society during the coming year, and, particularly, has recommended a plan for interesting the younger men in the activities of the Society.

A committee was appointed and continued to arrange for the purchase of a bust of the late James B. Eads, F. Am. Soc. C. E., to be placed in the Hall of Fame, of New York University, where the tablet was unveiled in 1921.

Early in the season, the Society was invited to appoint two representatives to meet with representatives of other technical societies, in an endeavor to form a Uniform Code of Ethics. This Committee reported, and the carrying out of its recommendations was referred to the incoming Board of Direction. In this connection, it was also recommended that a committee be appointed on professional conduct of members.

The possibility of establishing a new Employment Bureau was suggested by the Federated American Engineering Societies, and the Board of Direction appointed a representative to attend the meetings and report on the

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* See p. 194.

activities. This report is now being formulated and will be presented for final action at a later date. The President was appointed as one of the representatives of the Society at a meeting of the representatives of the other three Founder Societies, the American Society for Testing Materials, and the Engineers Club of Philadelphia, to be held in Philadelphia, Pa., on February 9th, 1922, to formulate plans for an International Congress to be held in Philadelphia in 1926. The appointment of another member of this Committee was also authorized.

Past-President Davis was appointed as a representative of the Society at a conference of Red Cross Societies concerning Flood Protection.

The next business will be a report of the Committee to Recommend the Award of Prizes and the action of the Board of Direction relative thereto. The Secretary will read the report.

"REPORT OF THE COMMITTEE TO RECOMMEND THE AWARD OF MEDALS AND PRIZES FOR THE YEAR 1921

"DECEMBER 17TH, 1921.

"MR. GEORGE S. WEBSTER,
President, AMERICAN SOCIETY OF CIVIL ENGINEERS,
33 West Thirty-ninth Street,
New York City, N. Y.

"SIR.—Under date of May 23d, 1921, Acting Secretary Elbert M. Chandler notified the subscribers hereto, namely, J. C. Nagle, H. L. Haehl, and W. Easby, Jr., that you had appointed them members of the Committee on Prizes for the year 1921. For reasons of geographical location, it has not been possible for the members of this Committee to meet in personal consultation, but by personal correspondence we have exchanged opinions regarding our estimates of the merits of the papers presented to us for consideration, and, as a result, we submit the following recommendations:

"1.—That no award of the NORMAN MEDAL be made for the year 1921.

"2.—That Fred A. Noetzli, Assoc. M. Am. Soc. C. E., be awarded the JAMES J. CROES MEDAL, for his paper on 'Gravity and Arch Action in Curved Dams'.

"3.—That Ernest E. Howard, M. Am. Soc. C. E., be awarded the THOMAS FITCH ROWLAND PRIZE, for his paper on 'Vertical Lift Bridges'.

"4.—That W. C. Curd, M. Am. Soc. C. E., be awarded the JAMES LAURIE PRIZE, for his paper on 'Bank Protection and Restoration; A Problem in Sedimentation'.

"5.—That no award of the ARTHUR M. WELLINGTON PRIZE be made for the year 1921, in the absence of specific rules formulated by the Board of Direction. Your Committee is of the opinion that neither of the two papers on transportation problems, which were submitted to the Committee for consideration, were of an unusually high order. However, should the rules of the Board of Direction provide that this prize be awarded for the 'most meritorious paper of the year' on the subject of transportation, we would then recommend that this prize be awarded to J. A. L. Waddell, M. Am. Soc. C. E., for his paper on 'Creeping of Railroad Rails'.

"6.—That L. Standish Hall, Jun. Am. Soc. C. E.,* be awarded the COLLINGWOOD PRIZE FOR JUNIORS, for his paper on 'The Probable Variations in Yearly Run-Off as Determined from a Study of California Streams'.

"Respectfully submitted,

"J. C. NAGLE,
"H. L. HAEHL,
"WM. EASBY, JR.,
"Committee on Prizes."

THE PRESIDENT.—The report of the Special Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, Mr. Robert A. Cummings, Chairman, is the next order of business.

(Mr. Cummings presented extracts from the Progress Report of the Committee.†)

ROBERT A. CUMMINGS, M. AM. SOC. C. E.—I move that the report be received and the Committee continued.

(Motion duly seconded.)

THE PRESIDENT.—The motion is that the report be received and the Committee continued. The motion is now open for discussion. If there is no discussion, all those in favor of receiving the report and continuing the Committee will give their assent by saying "aye"; contrary, "no". The "ayes" have it. The report is received and the Committee continued.

The Report of the Special Committee on Stresses in Railroad Track, Professor A. N. Talbot, Chairman.

A. N. TALBOT, PAST-PRESIDENT, AM. SOC. C. E.—The report is as follows:

"PROGRESS REPORT OF SPECIAL COMMITTEE TO REPORT ON STRESSES IN RAILROAD TRACK

"The Special Committee to Report on Stresses in Railroad Track, co-operating with similar committees of the American Railway Engineering Association and the American Railway Association, presents the following report of progress:

"The principal work of the year 1921 has been the reduction and correlation of the data of the field tests made in 1920. It will be recalled that tests were conducted on the tracks of the Illinois Central Railroad in Illinois, the Delaware, Lackawanna and Western Railroad in New Jersey, and the Atchison, Topeka, and Santa Fe Railroad in New Mexico and Iowa. These tests were made on tangent track and curved track, several different curvatures being used. A principal purpose of the tests was to find the effect of curvature of track on the stresses in the rail (including lateral bending stresses) caused by locomotives of different types run at different speeds, as compared with the stresses developed in straight track. The time required for the reduction of the large amount of data accumulated in the tests has been much greater than was anticipated. The work has been carried on steadily by the Staff, however, and good progress has been made. It is hoped that the Committee will be able to present another report during this year. The results found indicate that information of value on stresses developed in curved track may be expected. Another line of work carried on is the investigation of rail

* Now Assoc. M. Am. Soc. C. E.

† The Progress Report of this Committee will be published in *Proceedings* for March, 1922.

joints. Laboratory tests have been conducted with various types of rail joints, the purpose of the tests being to find the way in which the joints act and to learn the magnitude of stress developed in the various parts of the rail joint at ordinary wheel loads—a type of investigation that it is believed has not previously been attempted. A few field tests have been conducted on the Illinois Central Railroad to connect up the laboratory tests with the action of the joint in the track under wheel loads. Interesting results have been developed in the rail-joint tests.

"The Committee has a number of other questions under consideration.

"Respectfully submitted,

"The Special Committee on Stresses in Railroad Track,

"By A. N. Talbot, *Chairman.*"

Mr. President, I move that the report be received and the Committee continued.

(Motion duly seconded.)

The President.—Gentlemen, it has been moved and seconded that the report of the Special Committee on Stresses in Railroad Track be received and the Committee continued. Is there any discussion? All those in favor of the motion will give their assent by saying, "aye"; contrary, "no". It is so ordered.

Gentlemen, the time has arrived for the ceremony of conferring Honorary Membership. I shall ask the Committee in charge to come up on the platform. Gentlemen, the first certificate of Honorary Membership is to be awarded to M. Charles Prosper Eugene Schneider, of Paris, France, through His Excellency Jules J. Jusserand, Ambassador Extraordinary and Minister Plenipotentiary of France, represented by Brevet Major Dubreuil, Military Attaché to the French Embassy.

J. Vipond Davies, M. Am. Soc. C. E.—Mr. President and Gentlemen: I ask permission to present to you for the award of Honorary Membership, M. Charles Prosper Eugene Schneider. In the unavoidable absence of M. Schneider, he is represented here to-day by Brevet Major Dubreuil. The world owes a great debt to France for the mechanism of construction prior to the World War, as well as for its great participation in the war, in which Americans shared the burdens of the fight and the glories of the victory. To the honor of France and its glorious works, the Board of Direction has in its wisdom chosen as her representative the outstanding leader in the Profession of Engineering, M. Charles Prosper Eugene Schneider, upon whom to confer the highest dignity and honor which this Society can bestow, that of Honorary Membership. The work of M. Schneider, head of the great Creusot Works would entitle him to prominence in the profession. In large measure, the Society has already recognized the eminence of M. Schneider in the Profession of Engineering by participation in the award already made to him of the John Fritz Medal for the current year. In no less measure does M. Schneider deserve this recognition as one of the world's leading metallurgists for his work in the development of materials of construction, which is of such vital importance to the Engineering Profession. Since the conclusion of the war, M. Schneider has turned the resources of his great works to the

arts of peace, to the restoration of war damage, and to the development of modern industry. In honoring M. Schneider, we honor ourselves. I present him to you.

The President.—In recognition of the achievements of Charles Prosper Eugene Schneider in the Engineering Profession, as outlined by Mr. Davies, I have the honor, in behalf of the American Society of Civil Engineers and by authority of its Board of Direction, to present to you this certificate of Honorary Membership for M. Schneider. It is signed by the President and the Acting Secretary.

Brevet Major Dubreuil.—I thank you, Mr. President, and Gentlemen. I feel greatly honored to have been chosen by His Excellency M. Jusserand to represent France, M. Jusserand, and M. Schneider here. On this occasion, I cannot better express the gratitude of M. Schneider, and of France at large, than to read the following message that has been sent by M. Schneider for this occasion:

"To the Council and Members of the American Society of Civil Engineers I send most heartfelt thanks for the distinction you have conferred on me by electing me to Honorary Membership in the Society, an honor which I value very highly.

"I have big interests in the field of civil engineering, and none lies closer to my heart. Because of this community of feeling between us, I should have particularly enjoyed acknowledging in person the testimonial of this Honorary Membership.

"I like to think that this tribute to a Frenchman is addressed to the whole Engineering Profession of France, and is a new link between the civil engineers of our two countries, who have so often found admiration in each other's work. The Suez and Panama Canals will forever stand as testimonies to their achievements. Now, that we can again dedicate all our forces to works of peace, let us hope we shall accomplish still greater things for the benefit of the world."

The President.—The Certificate of Honorary Membership will now be presented to Luigi Luiggi, M. Am. Soc. C. E., through His Excellency, Vittorio Rolandi Ricci, Ambassador Extraordinary and Minister Plenipotentiary of Italy, represented by Commander T. F. Bernardi, Italian Consul-General in New York City. The Chair will recognize Mr. John William Lieb.

John William Lieb, M. Am. Soc. C. E.—Mr. President, Your Excellency, the Consul General of the Kingdom of Italy, Fellow Members of the American Society of Civil Engineers: I have the honor, sirs, of presenting to you *in absentia,* as an Honorary Member of this Society, Dr. Luigi Luiggi, Professor of Hydraulic Engineering at the University of Rome, Grand Officer of the Royal Order of the Crown of Italy, and Member of the Italian Parliament. An eminent civil and hydraulic engineer, Dr. Luiggi has rendered distinguished public service to his own country, and, through his professional achievements in many lands, has contributed notably to the advancement of the dignity and honor of our Profession. A cosmopolitan spirit, with a broad appreciation of beauty in design, excellence in workmanship, and adaptability to purpose in engineering construction, he is keenly alive to the growing importance which the engineer is assuming in the economic life of nations. He is himself a distinguished exemplar of the successful engineer achieving wide

recognition and attaining high public office. Dr. Luiggi is an ardent admirer of American engineering practice, and on the occasion of a recent visit to the United States, took occasion to inspect minutely the Catskill Aqueduct, east of the Hudson River, examining with much care the design, materials, and workmanship of the Kensico Dam, and manifesting the greatest pleasure at seeing the old Croton Dam about which he had lectured and had pictured to his students in the University of Rome for many years past, and which he now saw for the first time.

In thus honoring members of the Profession who have achieved distinction in foreign lands, this Society takes a further step forward in solidifying international professional relationships and makes effective the old saying that "science knows no geographical boundaries", by recognizing distinguished professional achievement in public service accomplished under any National flag.

It is, therefore, a distinguished honor, Sirs, to present Dr. Luiggi as a worthy addition to the many illustrious names on the list of Honorary Membership in the American Society of Civil Engineers, and I thank the Society most heartily on behalf of our Italian engineering confrères, for the distinguished compliment you have paid the Engineering Profession in Italy by the distinction you have now conferred on one of its most eminent and highly honored representatives.

The President.—In recognition of the achievements of Dr. Luigi Luiggi in the Engineering Profession, as outlined by Mr. Lieb, I have the honor, in behalf of the American Society of Civil Engineers and by authority of its Board of Direction, to present to you for Dr. Luigi Luiggi this certificate of Honorary Membership, which has been signed by the President and Acting Secretary of the Society.

Commander T. F. Bernardi.—Mr. Chairman, Distinguished Guests, and Gentlemen: It is a great privilege for me to accept in the name of His Excellency, the Italian Ambassador, the Certificate of Honorary Membership, which your Society has conferred on the Hon. Luigi Luiggi. I feel highly honored, and I wish I could express adequately my gratitude. Dr. Luiggi has already wired your distinguished President his thankful acceptance of the honor which has been conferred on him.

You are honoring one of the foremost Italian engineers of the day, and it seems to me that you should note with sympathy the fact that in Dr. Luiggi you are not only honoring a foreigner, an Italian, but you are honoring a descendant of those old Romans who built those aqueducts which to-day cross the Roman Campagna and which are in parts still utilized; and I am very happy to remind you that Dr. Luiggi teaches the science of engineering on the classical soil of Rome and under the shadow of these same aqueducts which furnished the first examples of engineering, and which to-day are the only examples of practical engineering which survive of the olden time.

I am sure this thought would be very gratifying to Dr. Luiggi himself. It certainly affords me great pleasure to place it before you. I renew in the

name of Dr. Luiggi, my most heartfelt thanks for the honor thus conferred on him.

The President.—The Certificate of Honorary Membership will now be presented to Samuel Rea, M. Am. Soc. C. E. The Chair recognizes Col. William J. Wilgus.

William J. Wilgus, M. Am. Soc. C. E.—Mr. President, among those selected for admission, on this occasion, to Honorary Membership in the Society, is one whose accomplishments as an engineer and administrator eminently fit him for that high degree. For fifty years he has been intimately associated with the Pennsylvania Railroad, with which he has risen from the lowly rank of Rodman to the proud position of President. To his technical skill and creative genius in a pronounced degree is to be credited not only the general development of that great system of transportation, but also many outstanding accomplishments, among which are numbered the monumental work that includes the entry of his Company into the heart of New York City and direct communication with New England, comprising those tunnels under the North and East Rivers, this development of stations on Manhattan, and the striking plan that connects New York and New England by the bridge at Hell Gate. It is with a deep sense of appreciation, Mr. President, that I now avail myself of the honor of presenting to you, our fellow member, Dr. Samuel Rea, President of the Pennsylvania Railroad.

The President.—Mr. Rea, in recognition of your achievements in the Engineering Profession, as outlined by Col. Wilgus, I have the honor, in behalf of the American Society of Civil Engineers, and by authority of the Board of Direction, to present to you this Certificate of Honorary Membership, which has been signed by the President and the Acting Secretary.

Samuel Rea, Hon. M. Am. Soc. C. E.—Mr. Chairman, Fellow Members of the Society: Among the most cherished associations of a rather long career, I have always cherished membership in this Society and taken a deep interest in its affairs; not so closely allied, but still another Society in which I have been interested for many years, and of which I have the honor to be a member, is the Institution of Civil Engineers. You may understand, therefore, my feelings at this time and my gratification at the recognition of whatever work I may have done, to warrant this honor and distinction which you have conferred on me, and which I regard as the greatest I have yet received. I thank you.

The President.—The Certificate of Honorary Membership is conferred on Mr. Ambrose Swasey. The Chair recognizes Mr. Charles T. Main.

Charles T. Main, M. Am. Soc. C. E.—Mr. President, it is my privilege and pleasure to present for Honorary Membership one who has been intimately connected with the Engineering Profession for many years, and who probably is more widely known therein than any other engineer in the United States.

He learned the machinist trade at Exeter, N. H., and, in 1870, entered the employ of the Pratt and Whitney Company. He soon had charge of the gear work for that Company, and, while in this position, he invented new and valuable machines for gear cutting.

In 1880, the firm of Warner and Swasey was formed in Cleveland, Ohio, and began the manufacture of machine tools.

In addition to this business, Warner and Swasey have given special attention to the construction of high-class astronomical instruments and have introduced many new features in the construction of equatorial telescopes, which have made them famous in the United States and abroad.

The man we are to honor has invented and perfected a dividing engine, capable of automatically dividing circles up to 40 in. in diameter, with an error of less than 1 sec. of arc, telescopic gun sights of various patterns, azimuth instruments, and other instruments of precision for use in sea-coast defense for the United States Government, and a range finder, known as the "Swasey range finder," for determining the position and distance of a ship or target within a range of 12 000 yd., which also has been adopted by the United States Government.

He has served in high office in many societies and organizations and on juries of award in the United States, has received honorary degrees and honorary memberships here and abroad, and has been decorated twice by the French Government.

He was the Chairman of the Engineering Delegation to England and France last year and as such did notable work in cementing the friendship between the engineers of Great Britain and France and the engineers of America.

He has established by generous gifts "The Engineering Foundation" for "the advancement of the Engineering Profession and the good of mankind."

In conferring Honorary Membership on representatives of other branches of the Profession, the Society broadens its scope of interest, which, in turn, tends to cement the friendship of the different branches of the Profession.

And now, to-day, Mr. President, the American Society of Civil Engineers is desirous of honoring this man—and itself—by conferring Honorary Membership on Ambrose Swasey.

The President.—Mr. Swasey, in recognition of your genius in the Engineering Profession, as outlined by Mr. Main, I have the honor, on behalf of the American Society of Civil Engineers and by authority of the Board of Direction, to present to you this Certificate of Honorary Membership, which has been signed by the President and Acting Secretary of the Society.

Ambrose Swasey, Hon. M. Am. Soc. C. E.—Mr. President, Mr. Main, Distinguished Guests, and Members: I appreciate indeed this high honor, and I am proud to become a member of your great Society, the history of which extends over a period of seventy years and which records among its members so many honorable men of the Alma Mater of the Engineering Profession of America. I am indeed very happy to receive this recognition and this new relationship, and I thank you most sincerely for the honor.

The President.—The Certificate of Honorary Membership will be conferred on Howard A. Carson, M. Am. Soc. C. E., through his representative, Mr. L. H. Davis. The Chair will recognize Mr. Harrison P. Eddy.

Harrison P. Eddy, M. Am. Soc. C. E.—Mr. President and Guests, Members of the American Society of Civil Engineers: It is a pleasure to have the

opportunity of presenting for the Certificate of Honorary Membership in this great Society, one of the pioneers of American engineering, Howard Adams Carson. Mr. Carson began his career about eighty years ago in the little town of Westfield, Mass., having been graduated from the Massachusetts Institute of Technology in its second class, in 1869. For a few years thereafter, Mr. Carson was engaged as Assistant Engineer in the City of Providence, in the Water-Works Department, and, later, in the Sewer Department. Shortly after that, he accepted the position of Superintendent of Construction on the Massachusetts Main Drainage Works, one of the earliest of the extensive sewerage works to be constructed in the United States. In that work, he came into intimate contact with heavy and difficult underground construction problems. It was only natural, therefore, in 1889, when the Metropolitan Sewerage District was organized to build the disposal works for the District in and around the City of Boston, that Mr. Carson should be selected as the Chief Engineer for that undertaking, a position which he held from 1889 until 1894, and during which he constructed many difficult underground structures which were among the first of their type to be built.

When the Transit Commission was organized in 1894, Mr. Carson was elected to serve as its Chief Engineer, and during the next fifteen years ending in 1909, he constructed the Tremont Street Subway, in Boston, the first electric car subway to be built in the United States, the East Boston Submarine Tunnel, the first of its kind in this country for that purpose, and the Washington Street Tunnel through the Bayside portion of the City of Boston.

During those years, Mr. Carson was recognized by his associates for his faithfulness and honesty, his tact and fairness, for his engineering skill and achievements; and it is only fitting that the members of this great Society should honor themselves by honoring him, and conferring on him the Certificate of Honorary Membership. I now have the great pleasure and the honor of presenting to you for the Certificate of Honorary Membership in the American Society of Civil Engineers, Howard Adams Carson, through his representative, Mr. L. H. Davis.

The President.—In recognition of the achievements of Mr. Carson in the Engineering Profession, as outlined by Mr. Eddy, I have the honor in behalf of the American Society of Civil Engineers and by authority of its Board of Direction, to present to Mr. Carson through you this Certificate of Honorary Membership which has been signed by the President and the Acting Secretary of the Society.

L. H. Davis, M. Am. Soc. C. E.—Mr. President, and Guests and Fellow Members of the American Society of Civil Engineers: It is a high honor and privilege to me to act to-day as representative of so eminent an engineer, so fine a man, and so true a friend as Mr. Carson. Mr. Carson has asked me to say that he is extremely grateful for the very high honor which this Society has conferred on him, and that he regrets very deeply that, on account of the state of his health, he is unable to leave the South where he is spending the winter, in order to be here to receive in person, this Certificate of Honorary Membership. He asks me further to say, and I want to say that it is characteristic of his modesty and generosity in so doing, that whatever success

has attended his labors was due in large measure to the able associates with whom he was connected and to the able hard-working colleagues whom he had associated with him. Mr. President and Gentlemen, on behalf of Mr. Carson, I thank you.

The President.—Gentlemen, this concludes the ceremonies of awarding the Certificates of Honorary Membership. We will proceed with the regular business of the Society. I invite the gentlemen to remain on the platform, if they wish. The report of the Special Committee on Highway Engineering, Mr. H. Eltinge Breed, Chairman. The Chairman cannot be present, and the report will be presented by Mr. Langthorn.

J. S. Langthorn, M. Am. Soc. C. E.—Mr. President and Members, I present herewith the Tentative Report of the Special Committee on Highway Engineering:

"Tentative Report of Special Committee on Highway Engineering

"The report of your Special Committee on Highway Engineering again relates chiefly to the functioning and co-operation of the Federal Bureau of Public Roads and the State Highway Departments.

"In last year's report, the Federal highway work was presented in some detail. The two significant features are:

"From 1917, when the first appropriation was made, to 1921, \$284 000 000 was appropriated for road work. In 1921, there was appropriated a sum of \$90 000 000, \$15 000 000 of it for forest roads, and \$75 000 000 for straight Federal Aid.

"Second, the Federal Aid appropriation has been made by law not to exceed 50% of the total estimated cost of the road, its maximum contribution to any State being \$20 000 per mile. The "fifty-fifty" basis holds except as the new law reads in appropriating \$75 000 000 for aid on Post Roads, 'that in the case of any State containing unappropriated public lands exceeding 5 per centum of the total area of all lands in the State, the share of the United States * * * shall not exceed 50 per centum of the total estimated cost thereof plus a percentage of such estimated cost equal to one-half of the percentage which the area of the unappropriated public lands in such State bears to the total area of such State.' According to this sliding scale of percentage, the amount of co-operation required from the Public Land States is decreased in proportion as the area of public lands within their borders is increased. The maximum percentage payable under this law in these States is: Arizona, 61.11; California, 59.32; Colorado, 56.13; Idaho, 58.01; Montana, 53.04; Nevada, 87.23; New Mexico, 61.51; Oregon, 61.13; Utah, 74.85; Wyoming, 64.65.

"The first recommendation of your Committee on Highway Engineering is that the existing relation between the Office of Public Roads and the various State Departments be continued, because the organization is effective and satisfactory results may be attained through it with reasonable rapidity.

"Second, the amount allotted per mile by the Federal Government should be increased from \$20 000 to \$25 000 per mile, with an additional contribution of one-half of any amount in excess of \$10 000 per mile required by grading, drainage, or structures. The legislative habit of appropriating dollar for dollar has tended to make \$40 000 roads a maximum product, often as uneconomic as it is thoughtless. Often the extra appropriation is necessary to meet unusual requirements of topography or traffic or to provide suitably for the more durable types of pavement. Failure to consider such needs and to make suitable provision for them means ultimate waste.

"Third, interstate roads and National routes should be paved with durable types where necessary to meet the traffic. Already some States are staggering under the burden of excessive maintenance charges where heavy traffic is falling on semi-durable pavements, and it begins to look as if the Government would have to take over some of the maintenance work in order to save its present investment. It has been proven that increased traffic follows an improved road, and the improvement, to justify its cost, must be strong enough to meet it.

"The last recommendation of your Committee is that the Society as a whole petition Congress for the passage of the bill now before it known as H. R. 8978, providing for an appropriation of $100 000 000 per year for the next five years.

"It is believed that the country as a whole will prosper appreciably through securing these roads, because they will help solve one of our most pressing economic problems, the problem of distribution.

"That the country will secure these roads more economically through a fixed appropriation for five years, because it will permit more comprehensive planning and greater continuity of organization both in Federal and State Departments.

"That such an appropriation will benefit not only Highway Engineers, as it will assuredly and directly, but also other branches of engineering dependent in however remote a degree on highway service and automotive transportation.

"Your Committee believes that should the American Society of Civil Engineers see fit to adopt these recommendations and to further them by whatever means it chooses, it will give a most helpful impetus to highway progress.

"This report is endorsed by every member of the Committee except Mr. John M. Goodell, who writes, 'I learn that there is no objection to my signing an endorsement of the continuation of Federal Aid for five more years. I am still reluctant, however, to sign more than that to present to the American Society of Civil Engineers.'

"H. Eltinge Breed,
"Chairman."

"Members of Committee:
"John M. Goodell,
"George W. Tillson,
"A. B. Fletcher."

I move an acceptance of this report and the continuance of the Committee.

Mr. Hudson.—I second the motion.

The President.—Gentlemen, you have heard the report. It has been moved and seconded that it be received and the Committee continued. Is there any discussion?

H. J. Sherman, M. Am. Soc. C. E.—I would like to ask whether or not, if this report is endorsed, it means that the Society stands back of the $100 000 000 appropriation?

Mr. Langthorn.—Mr. President, when I promised to read Mr. Breed's report, I did not think of the necessity of answering all questions that might be put to him. I would say from a general knowledge of this question that if this meeting adopts a resolution favoring this appropriation of $100 000 000 for five years, it would mean that it believes in that Federal appropriation. Does that answer the question?

Mr. Sherman.—Well, I do not know whether it does or not. I want to know whether if I vote for this report I commit myself and the members of

the Society to stand back of the proposed appropriation of $100 000 000 for five years.

MR. LANGTHORN.—Not at all.

THE PRESIDENT.—Any further discussion? All those in favor of receiving the report and continuing this Committee give their assent by saying, "aye"; contrary, "no". The "ayes" being in the majority, the report is received and the Committee continued. The Progress Report of the Special Committee on Bridge Design and Construction, Mr. Henry B. Seaman, Chairman.

HENRY B. SEAMAN, M. AM. SOC. C. E.—Mr. President, the report is very brief and it has been printed.* I move the adoption of the report and the continuance of the Committee.

MR. HUDSON.—I second the motion.

THE PRESIDENT.—It has been moved and seconded that the report of the Special Committee on Bridge Design and Construction be received and the Committee continued. Is there any discussion? All those in favor of receiving the report and continuing the Committee will give their assent by saying "aye"; contrary, "no". The "ayes" are in the majority, and it is, therefore, carried. The report of the Special Committee on Contract Standard Clauses, Mr. H. Eltinge Breed, the Chairman of this Committee, is absent, and the report will be presented by Mr. Langthorn, the Secretary of the Committee.

MR. LANGTHORN.—The report is as follows:

"PROGRESS REPORT OF THE SPECIAL COMMITTEE ON GENERAL FORM OF CONTRACT STANDARD CLAUSES.

"The Special Committee appointed by the American Society of Civil Engineers at its meeting in May, 1921, to consider the General Form of Contract Standard Clauses is organized and about to hold its first meeting, on January 19th, 1922. The very much regretted delay in getting to work has been due to exigencies beyond the control of the Committee.

"The time, however, has not been lost. The work and the failures of this past season have proved more conclusively than ever the need of greater standardization in contract clauses, to prevent grave misapprehensions in a rapid reading, and to save the time and meticulous attention to detail now necessary for a safe reading. A danger lies in similar clauses in different contracts that, actually made quite different in intent by a word or a punctuation mark, appear deceptively alike.

"That these difficulties are widely felt is evidenced by the conference called in Washington last month by Gen. Marshall, Jr., of the Associated General Contractors of America, and furthered by Secretary Hoover, to discuss the desirability and practicability of securing greater uniformity in forms of contract for construction work. A report of the first session of this conference made by Mr. J. S. Langthorn is appended.† A second session of this Conference will soon meet, and it is hoped that your Committee will have formulated a plan of co-operation with it.

"The report of the actual work of the Committee now beginning and its recommendations will be made as soon as possible."

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 683.

† An abstract of this Report is printed in *Proceedings*, Am. Soc. C. E., January, 1922, p. 11.

Mr. President, I move the adoption of this report and the continuance of the Committee.

(Motion duly seconded.)

The President.—It is moved and seconded that the report be received and the Committee continued. Any discussion? All those in favor of the motion will give their assent by saying "aye"; contrary, "no". The motion is carried. The report of the Alfred Noble Memorial Committee, Mr. Samuel Rea, Chairman; I understand that Mr. George Gibbs will make the report.

George Gibbs, M. Am. Soc. C. E.—Mr. President, I present the report of the Alfred Noble Memorial Committee as follows:

"Philadelphia, January 13, 1922.

"American Society of Civil Engineers,
"33 West 39th Street, New York City.

"Gentlemen.—The Alfred Noble Memorial Committee presented at the Annual Convention of the Society, held at Houston, Tex., in May, 1921, a report setting forth the status of the Committee's work at that date, and submits herewith a further report of progress.

"A formal meeting of the Committee was held in New York City on May 23d, 1921, and a sub-committee was appointed to meet with Mr. Paul Bartlett, the Sculptor, with a view of discussing certain changes in details of the memorial design. As a result, Mr. Bartlett has conferred with Mr. Glenn Brown, the Architect, regarding the proposed revision of the design; Mr. Bartlett has also discussed the subject with two eminent architects and obtained constructive criticism from them. The meetings above mentioned have resulted in certain changes in the memorial, but as the matter now stands the Committee is not yet prepared to submit to the Society a matured design finally approved by them.

"Also, in view of present financial conditions and the continued high cost of labor and materials, the Committee has not thought it desirable to hurry the determination of a final design, as it is thought preferable to devote the time available to working up an appropriate memorial scheme, and to await improved conditions before submitting a plan which may be the basis for soliciting subscriptions from the members of the American Society of Civil Engineers, and associated societies, for the completion of the memorial.

"Through an oversight in giving the Committee membership in the last report, the name of Gen. Harts was omitted; the Chairman has written Gen. Harts explaining the situation and asking him to continue to serve; reply has been received stating that he will be glad to serve and render all possible assistance in helping matters along. The Committee as now constituted consists of the following members: Samuel Rea, *Chairman,* Robert Ridgway, *Secretary* and *Treasurer,* Onward Bates, George S. Webster, *ex-officio,* George Gibbs, F. H. Newell, Hugh L. Cooper, Gen. William W. Harts, and S. H. Hedges.

"Respectfully submitted,
"Samuel Rea,
"Chairman."

Mr. Chairman, I submit the report for adoption and request the continuance of the Committee.

(Motion duly seconded.)

The President.—It is moved and seconded that the report be received and the Committee continued. Any discussion? If not, all those in favor will give their assent by saying "aye"; contrary, "no". The motion is carried.

The Counsel of the Society have advised that it is necessary for the Society to pass a resolution changing the number of Directors as provided in the new Constitution, and that this action be taken before the announcement of the election of officers. I will ask the Acting Secretary to present the resolution.

The Acting Secretary.—This resolution which was prepared by Parker and Aaron, Counsel for the Society, is as follows:

"*Resolved,* That the American Society of Civil Engineers, a membership corporation, organized under the laws of the State of New York, does, pursuant to the provisions of Section 14 of Chapter 40 of the Laws of 1909, as amended by Chapter 577 of the laws of 1921, hereby determine to change the number of its directors as follows, to wit:

"The Board of Direction, in which the government of the Society shall be vested and who shall constitute the Trustees provided for by the laws under which the Society is organized, shall hereafter be twenty-five (25) in number and shall consist of and be constituted of the President, the four (4) Vice-Presidents, eighteen (18) Directors, and the two (2) latest living Past-Presidents continuing to be members of the Society.

"*Further Resolved,* That the President and Secretary of this meeting be authorized and directed to sign, acknowledge and file a certificate specifying the foregoing determination and the number of Directors."

Arthur P. Davis, Past-President, Am. Soc. C. E.—I move the adoption of the resolution.

(Motion duly seconded.)

The President.—It is moved and seconded that the resolution be adopted. Any discussion? If not, all those in favor will give their assent by saying, "aye"; contrary, "no". The resolution is adopted. Discussion of the proposed Amendments to the Constitution, submitted to the membership on November 23d, 1921, is now in order.

The Acting Secretary.—Mr. President, the proposed amendments have been sent to the membership and have also been published in *Proceedings* for December, 1921. They appear in two groups. The first group was prepared by the Executive Committee and the Society's Counsel, and has been presented on the petition of the majority of the members of the Board of Direction and members of the Retired Committee on Referred Amendments. The purpose is to clarify certain minor inconsistencies in the revised Constitution.

The President.—Gentlemen, do you wish to act on these separately?

Mr. Hudson.—Mr. President, I move we act on them separately.

(Motion duly seconded.)

The President.—It is moved and seconded that we act on the groups separately. Those in favor of the motion will give their assent by saying, "aye"; contrary, "no." It is so ordered. We will take up Group 1, the amendments offered by the Executive Committee of the Board of Direction to correct minor matters in the Constitution.

Richard L. Humphrey, M. Am. Soc. C. E.—I move they be sent out to letter-ballot.

J. N. Chester, M. Am. Soc. C. E.—In order to bring the matter properly before the meeting, these amendments should be read in detail.

The Acting Secretary.—"Amend Article II.—Membership: Add Section below, and renumber present Section 9 Section 10:

"9.—The membership status of members of the Society in any grade, as it was immediately prior to November fifth, 1921, shall not be affected by amendments to the Constitution taking effect on that date, except that the Associates at that time shall thereafter be termed Affiliates."

Mr. Chester.—I move the adoption of that amendment.

Mr. Hudson.—I move to amend that, and move that this amendment be sent out with the recommendation of this meeting that it be approved.

(Motion duly seconded.)

Mr. Chester.—I accept that amendment.

The President.—It is moved and seconded that this amendment be submitted to letter-ballot with the recommendation of this meeting that it be approved.

(Motion duly seconded.)

The President.—All those in favor of the motion will give their assent by saying, "aye"; contrary, "no". The "ayes" have it and it will be so sent out.

The Acting Secretary.—"Amend Article IV.—Dues: Amend Section 3 by inserting after the first paragraph the following:

"Members residing outside of North America shall pay annual dues as follows: by Corporate Members, twenty dollars; Affiliates, fifteen dollars; Juniors, ten dollars."

The purpose of that proposed amendment is to make certain that there is no question about collecting dues from foreign members.

Mr. Hudson.—I move that this amendment also be sent to letter-ballot with the recommendation of this meeting that it be approved by the membership.

(Motion duly seconded.)

The President.—It is moved and seconded that this amendment be sent out to letter-ballot with the recommendation of this meeting that it be approved. Are you ready for the question? All those in favor will give their assent by saying "aye"; contrary, "no". It is so ordered to be sent out.

The Acting Secretary.—"Amend Article VII.—Nomination and Election of Officers:

"Amend Section 4, by inserting in 15th line before the words 'No vote', 'In the first and second canvasses for Official Nominees', making the sentence read:

"In the first and second canvasses for Official Nominees no vote of a Corporate Member for a nominee for Vice-President resident outside of the zone in which the voter resides shall be counted; no vote of a Corporate Member for a nominee for Director resident outside of the district in which the voter resides shall be counted."

Mr. Hudson.—I move that this amendment be sent out to letter-ballot with the approval of this meeting.

(Motion duly seconded.)

The President.—It is moved and seconded—

A Member.—What is the use of sending these amendments out to letter-ballot?

The President.—The Constitution requires it. All those in favor of the motion give their assent by saying "aye"; contrary, "no". The "ayes" have it. We shall now take up the second group.

John P. Hogan, M. Am. Soc. C. E.—Mr. President, I move that the reading of the second group of amendments be dispensed with. They have been printed and sent out to the membership and have been in their hands for thirty days.

(Motion duly seconded.)

The President.—The motion is that the reading of the second group of amendments be dispensed with as they have been sent out to the membership. It has been seconded.

A Member.—They may have been sent out, but very few remember them.

A Member.—Is there not conflict between that first and second group? And is it not the object of presenting them at this meeting to clear up that conflict, if we can, before they are sent out? In other words, so that amendments that go out to the membership may be voted on without delay. Is not that the purpose of submitting them to this meeting? Is not the discussion of that amendment in order?

The President.—We have a motion before the house. All those in favor of dispensing with the reading of the amendments in the second group will give their assent by saying, "aye"; contrary, "no". The "noes" appear to have it. Unless there is a division called for, the Chair will decide that the "noes" are in the majority and the Acting Secretary will proceed to read the second group of amendments.

The Acting Secretary.—"Amend Article VII.—Nomination and Election of Officers:

"Amend Section 1, by striking out of the first paragraph the sentence:

"Members not residing in North America shall be allocated to District No. 1."

Mr. Humphrey.—Mr. President, I move that this amendment be sent out to letter-ballot. I want to say, Mr. President, that in the districting of the Society it throws into District No. 1, under the Constitution, approximately 2 181 members. Now, it does seem illogical to put men who have their places of business in China, Japan, Australia, and the Orient into the New York District. Members who reside in Canada and Mexico, and other parts of the North American Continent, are put into the districts to which they are contiguous. It would seem logical, therefore, that those members outside of the United States without distinction should be put into those districts to which they are naturally contiguous, and it would simplify the districting of the Society. There are in District No. 1 at the present time resident here 1 606 members. The number is increasing. Why we should add all those foreign members to that District seems to be illogical. Therefore, for the purpose of simplifying that, we should distribute those members living outside of North America just the same as we distribute those living outside of the United States, to the districts to which they are naturally contiguous.

(Motion duly seconded.)

The President.—It has been moved and seconded that the amendment be sent out to letter-ballot. The subject is now open for discussion.

P. H. Norcross, M. Am. Soc. C. E.—Mr. President, I offer as an amendment to that motion that this amendment be referred to the Old Committee on Referred Amendments, which, under the Constitution, will have to report back at the next Annual Convention any discussion of that amendment and numerous other amendments that will probably be discussed this morning. I beg a moment's time to express what I think is the opinion of the members of the Committee and probably of a great many members of the Society relative to the new Constitution, which, under the ruling of the attorneys, became effective on November 5th, 1921. It had not had time to draw one breath before amendments to it were offered. I plead with the members of the Society for an opportunity for the new Constitution to have at least one year of grace, in which to prove whether it is functioning as a new Constitution or is a "flash in the pan". These remarks will apply equally to the second group of amendments which the Acting Secretary will read and which will probably be discussed at length, but which can be eliminated by acting promptly in accordance with the suggestion which I have made. I, therefore, in offering this amendment, suggest that this amendment be referred to the old Committee on Referred Amendments.

Mr. Hudson.—Mr. President, I move to amend, that this amendment be sent to the vote of the Society with the adverse recommendation of this meeting. We have already discussed this matter. Mr. Humphrey spoke in support of his motion. I believe that the foreign members of this Society prefer to be attached to District No. 1, the district in which the office of the Society is located. It is much more convenient for them to correspond with the Society in connection with papers and other affairs, and they should not be attached to the fifteen districts throughout the country, but should be attached to District No. 1. We have already voted on this same amendment. It was voted down at the Annual Convention at Houston.

L. D. Rights, M. Am. Soc. C. E.—I second that motion.

The President.—The latest amendment is that this amendment to the Constitution be sent out to ballot, with the recommendation of this meeting that it be not approved. I think that is correct, Mr. Hudson, your recommendation was that it be sent out to a vote of the Society with the recommendation that it be not approved? Any discussion on this motion? All those in favor of the second amendment will give their assent by saying "aye"; contrary, "no". The "ayes" appear to have it. The amendment is carried. I think that disposes of the other amendment.

The Acting Secretary.—"Amend Section 4,—

A Member.—I rise to a point of order. Is it not proper that we vote on the original motion as amended?

The President.—I suppose it is, if you desire to. The question has been asked, should we not now vote on the original question as amended. All those in favor give their assent by saying "aye"; contrary, "no". The motion is carried.

The Acting Secretary.—"Amend Section 4, by striking out—

A Member.—I did not have a chance to vote on the other.

The President.—I called for the vote on the negative side.

The Acting Secretary.—"Amend Section 4, by striking out the first paragraph and substituting the following:

"Directors shall be nominated by the Corporate Membership of the geographical districts which they are to represent, and may or may not be resident therein.

"Not later than the fifteenth day of April each year there shall assemble in such geographical districts as are entitled to nominate a Director, and in such zones as are entitled to nominate a Vice-President, representatives chosen by the Local Sections therein, which representatives shall have voting power in proportion to the respective memberships of the Local Sections represented.

"These representatives shall constitute the District or Zone Board and shall nominate a candidate or candidates for the office of Director for the said District or for the office of Vice-President for the said Zone and make announcement thereof to the District or Zone membership.

"If there be but one Local Section in the District said Section may nominate its candidate or candidates for Director in such manner, subject to the approval of the Board of Direction, as it may choose.

"Additional nominations may be made by declaration by at least twenty-five Corporate Members of said District or of said Zone forwarded to the said District or Zone Board within twenty days following said announcement.

"A letter ballot containing the names of the candidates so nominated, upon which the nominees of the District or Zone Board shall be designated, shall be mailed by said Board to each Corporate Member in the District or in the Zone not later than May fifteenth, and the ballots received prior to June tenth shall be canvassed by the said Board, and a report of the result thereof, certified by the said Board, shall be presented by the representatives of the Local Sections of said District or of said Zone to the Annual Conference of Representatives of Local Sections."

Mr. Norcross.—I move that this amendment be sent out to a vote with the recommendation of this meeting that it be adverse.

(Motion duly seconded.)

William T. Walker, M. Am. Soc. C. E.—Walker is my name and I come from Minneapolis. I am glad to see that amendment come up. We have what is known as the Northwestern Section of the American Society of Civil Engineers. There are in the Twin Cities about 100 Members and Associate Members of the Society and the Section was organized in 1914. We have good meetings if something of interest comes up; if, however, there is nothing of special interest, the attendance is very poor. In 1919, a series of excellent meetings was held, because of the interest in getting the Annual Convention in St. Paul and Minneapolis, which we finally did. In October, 1921, at the first meeting, the really important meeting of the year, at which an election of officers was held, there were fourteen members present. The Society has to give these Local Sections some responsibility, or they will cease to exist. To come to a meeting and probably have a dinner and talk over things generally is not going to get the Section anywhere. There is wholly a lack of interest in the Section. I am speaking now for the Twin Cities. You cannot expect members out there to pay $20 for their membership and then $5 more, and, in addition, the cost of the dinner at the meetings. We simply have to have some financial aid from the Parent Society. Now, this responsibility

that was put on the Sections of nominating a Director represents a little bit of an advance, but I think you should put more responsibility on those Sections and give their members a chance to feel that they are really a part of the Society.

Mr. Hogan.—The assumption that putting this responsibility on the Sections will get the members out to meetings is not borne out by the experience of the American Society of Mechanical Engineers. It has a system somewhat similar to that proposed here. I will cite the experience of the Utica District. The Utica District Local Section shows 150 members, who are scattered from Plattsburg to Ogdensburg. It is easier for a man in Ogdensburg to get to New York City than to get to Utica. The result is that there are only 47 of the 150 members of the Section who are within two hours of Utica. At the last meetings called for the purpose of electing representatives, there were present for the last year and a half 8, 8, and 6 members, respectively.

Mr. Humphrey.—The recommendation that is now before the Annual Meeting is one made by the Committee on Development that was appointed by this Society and made a unanimous recommendation as regards this particular form of procedure. It was passed by the Annual Meeting of two years ago by a favorable vote. It received about seven or six to one vote as to the policy, and received nearly a two-thirds vote of the ballot of 1920. Col. Hogan has said that this did not work out in the American Society of Mechanical Engineers. I have been informed by the Secretary of that Society that the Annual Meeting of the Sections of that Society brought representatives from all those Sections; that they had an extremely interesting meeting. They act as a sort of House of Representatives, and pass on to the Council things which they think should be done. This plan differs from the plan of the Mechanical Engineers in this particular, it is not necessary for the members of the Sections to get together, as Col. Hogan's remark implied. Each Section can delegate its representative, who meets with the representatives of other Sections in the District, to determine whom they want to nominate to the office of director, or in the case of the zone, for the office of vice-president. If the nominations of this body of representatives is not satisfactory, there is still the provision that they can nominate other candidates by declaration of twenty-five men. It does give, as Mr. Walker has stated, something of interest to the Local Sections. The Society for years has been somewhat like an ostrich, and the members of this District No. 1 think the whole body of the Society is carried therein. I was asked this morning by the President of one of the Local Sections whether something could not be done by which the Presidents could get together informally or otherwise, and whether an announcement could not be made by the Chair fixing a time at which representatives of the Local Sections could confer on meetings and stimulate the work of the Society.

I have pleaded before this Society for the Local Sections. I speak for the Philadelphia Section, when I say we want this kind of legislation. We do not ask that this meeting shall vote favorably. We are satisfied to have the motion that was offered by Mr. Norcross go out, with the unfavorable recommendation of the meeting; but we do want this question to go to the members

of the Society and that the members of the Society determine whether or not they want this organization to function this way.

Mr. Norcross.—Mr. President, I appreciate the remarks of the gentleman from Minneapolis. I am afraid, however, that most of the discussion is beside the real point at issue. As I stated a few moments ago, you have just voted into life a new Constitution. The Committee has provided in that Constitution machinery which it is hoped will stimulate activity in Local Sections. We spent approximately $6 000 in mileage. A Committee of Eight, from Boston on the east to San Francisco on the west, covered 64 000 miles during 1920 and 1921; conferences were had with Sections, with individuals, with members of the Board of Direction, and a new Constitution was drafted and is now effective. Before that Constitution has had time to show its effectiveness or its inability to function, new amendments are offered relegating to the scrap pile what you have spent $6 000 of the Society's funds to get. You have revised your whole clerical organization to make it function. I, therefore, plead with this body to send it out with an adverse report; and I beg of you to give this new Constitution at least twelve months in which to show that it has virtue.

Mr. Walker.—I just want to ask the indulgence of the meeting for a moment. Mr. Norcross just spoke about the expense. I believe that I can personally guarantee that if the members outside of this District know, or rather the prospective members outside of this District know, that they are really going to be a part of this Society, that we can get new membership around the Twin Cities to the extent of thirty-five members, and that is $700. I do not believe it is going to cost that much.

Clemens Herschel, Past-President, Am. Soc. C. E.—Mr. President, I want to second what Mr. Norcross has said. As a matter of hearsay, I will say to you that this subject of a new Constitution has been to my knowledge before this Society for more than five years. We have spent a great deal of time on it. The members have done a great deal of work on it. Is it not reasonable, is it not sensible, is it not the only way to do business, when you have a new Constitution, which, in the nature of human things cannot be put before you as perfect, that you give it a trial to see how it works? The only thing in my mind to be done in this case is to take that whole Group II and lay it on the table.

Mr. Chester.—Mr. President, while I have the utmost sympathy for all that Mr. Norcross has said, and all that our Past-President, Mr. Herschel, has said with respect to this Constitution, those of you who were present at Houston, when this matter was being adopted and some slight amendments were brought up there, will remember that Mr. Norcross and the remainder of the Committee used the one argument that if we started to amend this Constitution then in the slightest way it would probably defeat the whole thing. We were all of accord, as was said here yesterday, or last night at the Officers' meeting, that this Constitution, we all recognized, was better than the old one, and the thing to do was to get it into operation, and then we could make slight amendments, and cause it to function in a way that would be satisfactory to the majority of the Society. Mr. Norcross, in addressing you

here to-day, does not say a word about the fact that this new Constitution omitted to assess members, non-resident of the United States, or some group was omitted altogether, and that this amendment is absolutely necessary to restore the funds of this Society. If one amendment is necessary, and that one certainly is, why should not the remainder be considered? Why, if the Committee made one mistake, and a gross one, might it not have made others? Is it not the function of this meeting and the right of every member to discuss or to propose other amendments when they think them necessary?

As regards the experience with Sections, I represent Pittsburgh, and our position is much the same as that stated by Mr. Walker who comes from the Twin Cities; and as regards the American Society of Mechanical Engineers, I am on the Executive Committee of the Pittsburgh Section of that Society. They are having no trouble such as the Utica men report, but they only need something to interest them. They only need to be made feel that they are part and parcel of the whole. I hold no brief for any one of these amendments. I do believe in our right to amend that Constitution. I believe it is right to make the first amendment and get dues assessed on the members who were omitted. That goes without argument; but if that is right, there certainly must be some others that we have a right to discuss and a right to send out to ballot; and as has been expressed here, the General Headquarters of this Society being in the City of New York, in District No. 1, it is apparent that if the interests of District No. 1 are served at the expense of the remainder of the country, it is likely to have an adverse or contrary effect on the other districts and on the far-away members. So that I feel that the sentiment of this meeting, held here in the heart of District No. 1, is not representative of the majority of the membership. To express the opinion of this meeting is all right, but we must not strangle the getting out of these amendments as expressed by Past-President Herschel.

De F. A. Wheelock, M. Am. Soc. C. E.—I do not desire to take up any time except to say this, we are a deliberative body composed of a large membership, in which every member should have a voice in its deliberation and in its action. I do not think there is any criticism of the Committee that prepared this new Constitution. It is an improvement. We all adopted it. One is to blame as much as another. My point is this, I cannot see the source of the objection to sending out these amendments to letter-ballot among the membership, a very small portion of which, among the New York membership, is represented in this body to-day. I believe we are a democratic body, and the majority should rule. If you bought a new car, in which the manufacturer had put his best efforts and his best materials in order to give you a perfect car, you would not run that for a week or for a month or a year to give it a trial; if you found something wrong with it, you would get him to correct it at once. If you have a small blow-out somewhere in this Constitution, is it not proper to submit it to the membership for their consideration by letter-ballot in order to correct it?

Mr. Norcross.—We corrected the blow-out in the first group of amendments.

The President.—It is moved and seconded that this group be sent out to letter-ballot with the unfavorable recommendation of this gathering. All those in favor of the motion give their assent by saying "aye"; contrary, "no". The "ayes" appear to have it. The motion is carried.

The Acting Secretary.—"Amend Section 4, by striking out the word 'President' in the first line of the second paragraph so that the paragraph will read as follows:

"In the event of a tie vote for nominee for Vice-President or Director the names of the persons receiving such tie vote shall be placed on the ticket as 'Official Nominees'."

Mr. Humphrey.—I move that it be sent out to letter-ballot.

(Motion duly seconded.)

Mr. Rights.—Mr. President, I would like to amend that, with the adverse recommendation of this meeting.

(Motion duly seconded.)

The President.—The motion is that this amendment be sent out to letter-ballot, with the adverse vote of this meeting. Is there any discussion? All those in favor of the amendment will give their assent by saying "aye". The "ayes" appear to have it. Unless a division is called for, I will decide that the "ayes" are in the majority. We will now vote on the original question as amended. Those in favor will give their assent by saying "aye"; contrary, "no". The "ayes" appear to have it. The "ayes" have it. We will proceed with the reading of the amendments.

The Acting Secretary.—"Add after Section 4 a new Section to read as follows:

"5.—The hereinafter provided Annual Conference of Representatives of Local Sections at which the representatives shall have voting power in proportion to the respective memberships of the Local Sections represented, shall nominate one or more candidates to fill the office of President to be elected at the next annual election; the written acceptance of each candidate must be obtained prior to his nomination.

"A list of said nominations, together with the list of the nominations for Directors by the several geographical districts, and of the nominations for Vice-Presidents by the several Zones, certified by the Chairman and the Secretary of the said Conference, shall be presented to the Board of Direction not later than the fifteenth day of September.

"The nominations thus made to be known as the 'Official Nominations' shall be such as to provide, with the officers holding over, the officers provided for in Article V."

Mr. Humphrey.—I move that this be sent out to letter-ballot.

(Motion duly seconded.)

Mr. Rights.—I would like to amend that, with the adverse recommendation of this meeting.

(Motion duly seconded.)

The President.—Are you ready for the question? The vote will be on the amendment that is to be sent out with the adverse recommendation of this meeting. Any discussion? All those in favor of the amendment will give their assent by saying "aye"; contrary, "no". The "ayes" appear to have it.

Unless a division is called for, I will decide that the "ayes" have it. The amendment is carried. The vote will now be on the motion as amended, that it be sent out to letter-ballot with the adverse recommendation of this meeting. All those in favor of the motion will give their assent by saying "aye"; contrary, "no". The "ayes" have it. The motion is carried.

The Acting Secretary.—"Re-number Sections 5, 7, 8, 9, and 10, and amend Section 6 to read Section 7, and strike out in the second paragraph the words 'showing also thereon the results of the "second ballot"'."

Mr. Humphrey.—I move that it be sent out to letter-ballot.

(Motion duly seconded.)

The President.—It is moved and seconded—

Mr. Rights.—I would like to amend again, with the adverse recommendation of this meeting.

The President.—The vote will be on the amendment. All those in favor of the motion being sent out with the adverse recommendation will give their assent by saying, "aye"; contrary, "no". The "ayes" appear to have it. Unless there is a division called for, I will decided that the "ayes" have carried it. The vote will now be on the original motion as amended. All those in favor will give their assent by saying "aye"; contrary, "no"; the "ayes" have carried it. We will now proceed with the next amendment.

The Acting Secretary.—"Amend Article VIII.—Meetings: Add a new section to read as follows:

"5.—There shall be held, during the month of July or August, an Annual Conference of Representatives from the Local Sections to consider the welfare of the Society and its members and to report thereon to the Board of Direction; one representative thereto from each section shall be allowed traveling expenses within Continental United States on a mileage basis.

"The Annual Conference of Representatives of Local Sections shall elect from among its members a Chairman and a Secretary to serve for one year beginning on the first day of the following November. At said Annual Conference a majority of the representatives shall constitute a quorum; if at said Annual Conference a quorum is not present, then such representatives as are present shall call an adjourned meeting."

Mr. Humphrey.—I move that that be sent out to letter-ballot.

Gardner S. Williams, M. Am. Soc. C. E.—I second the motion.

The President.—It is moved and seconded—

Mr. Rights.—I move an amendment again, with the adverse recommendation of this meeting.

(Motion duly seconded.)

The President.—Any discussion on the amendment? If not, we will vote on the amendment. All those in favor will give their assent by saying "aye"; contrary, "no". The Chair believes that the "ayes" are in the majority. Unless there is a division called for, he will so decide. There being no division called for, it is decided in the affirmative. The vote will now be on the original motion as amended. All those in favor will give their assent by saying, "aye"; contrary, "no". The motion is carried. The "ayes" are in the majority.

THE ACTING SECRETARY.—"Amend Article IX.—Local Sections: Strike out the first paragraph and substitute the following:

"There shall be established in each geographical district of the Society one or more Local Sections. These Sections shall have powers and act under such rules and regulations as the Board of Direction may prescribe.

"Each member of the Society shall identify himself with a Local Section in the district in which he resides, or, in default of voluntary action, shall be assigned to the most suitable section in said district by the Board of Direction."

"Strike out of the second paragraph the word 'may' in the first line and substitute the word 'shall'."

MR. HUMPHREY.—I move that that be sent out to letter-ballot.

MR. WILLIAMS.—I second it.

MR. RIGHTS.—I would like again to amend, with the adverse recommendation of this meeting.

MR. HERSCHEL.—I second it.

THE PRESIDENT.—The vote will be on the amendment. All those in favor will give their assent by saying "aye"; contrary, "no". The "ayes" appear to be in the majority; unless there is a division called for, the Chair will so decide.

MR. HUMPHREY.—On this motion I would like to have a division.

THE PRESIDENT.—Those in favor of the amendment will please hold up their hands. All those opposed, hold up their hands; 207 in the affirmative and 36 in the negative.

MR. WALKER.—Just as a matter of interest—

THE PRESIDENT.—We have another motion before the house. The vote will now be taken on the motion as amended. All those in favor will give their assent by saying "aye"; contrary, "no". The original motion as amended is carried.

Mr. Walker, I understand that is the last amendment. Have you anything you wish to say?

MR. WALKER.—Just as a matter of interest, I would like to know how many in the audience voting reside outside of District No. 1, and how many in District No. 1.

MR. HUMPHREY.—I would suggest that a show of hands of those outside District No. 1 would be sufficient.

THE PRESIDENT.—The registration will show the number of visitors and the number of those residing in New York.

MR. WALKER.—The point I wish to make is this, that the majority of the members reside outside of the First District, and yet of those present at this meeting probably three-quarters are from the First District.

MR. HERSCHEL.—Mr. President, I have the utmost sympathy and have had, ever since I have been a member of this Society, and that is 53 years, with the interests of members outside of the First District. I, myself, have been a member of the First District only in the last 30 years.

Now, as sometimes happens, some of the thoughts that I wanted to put into my previous remarks came to me after I had sat down, and one of those is that the trend of thought and prospective action of this Society is all in the direction of building up the Local Sections. I ask my friend from the

Twin Cities to put that "in his pipe and smoke it" and report it when he gets home. Looking to the future of the Society, there has been nothing to which the Board of Direction has given more thought than that very point; and every man here who does not belong to District No. 1 may go home feeling assured that under the new Constitution, which allows and was built up for the purpose of bettering the condition of the Local Sections, and increasing their numbers, they will have the whole attention of the Board of Direction in the future. That is the trend of thought now, and I have not the slightest doubt that it will so continue.

Merritt H. Smith, M. Am. Soc. C. E.—Mr. President and Gentlemen, as one who voted in favor of the amendment and in favor of the motion as amended, I want to second the motion of the gentleman from Minneapolis, to take a vote as to how many are here from District No. 1, and those who are here from a distance. I can see no reason why that is not good information to send out to the membership of this Society, no matter where they live.

The President.—That will be all shown by the registration, and will go out in the *Proceedings*.

John F. O'Rourke, M. Am. Soc. C. E.—I do not think it will show the people who are not voting. The registration will not show whether you voted or not.

Mr. Smith.—If I may be permitted, I understand that Mr. Walker from Minneapolis made a motion—

The President.—He made no motion.

Mr. Walker.—Only a suggestion, I will, however, make a motion.

Mr. Smith.—And I will second it.

The President.—There is no motion at present before the house. Mr. Walker has not made a motion.

Mr. Eddy.—I voted for the amendment as an amendment. I am not from District No. 1. I think that it is courteous that we have a division here to show how many members are from District No. 1 and how many are from the outside, and I make that motion.

Mr. Smith.—And I second it, Mr. President.

The President.—The motion is that a canvass be made to determine how many members in this room are from District No. 1, by a show of hands.

A Member.—And how many from other districts.

The President.—Are you ready for the question? All those in favor give their assent by saying, "aye"; contrary, "no". The motion is carried. Will those from District No. 1 hold up their hands, and we will have a canvass made.

All those outside the District will hold up their hands, and we will make another count. The count shows 223 from District No. 1 and 150 from outside. Gentlemen, we will now proceed with the business of the meeting, and the Acting Secretary will make an announcement.

The Acting Secretary.—The President has requested that this announcement, which has been presented to him, be made: The Presidents and Chairmen of the various Local Sections are invited to attend an informal meeting at 9 o'clock to-morrow morning. No place is designated. I assume that the Past-Presidents' Room will be satisfactory.

Mr. Talbot.—The Past-Presidents' Room has been assigned at 10 o'clock to another Committee.

The President.—That Committee meets at 9 o'clock and will probably be through by that time. If not, other arrangements will be made.

The Acting Secretary.—In accordance with the usual custom, I will announce the election and transfer of members by the Board of Direction at its meetings of January 16th and 20th, 1922, as follows:

As Members

Theodore Bloecher, Jr., Baltimore, Md.
Arthur Norbert Blum, Philadelphia, Pa.
James Bolton, Richmond, Va.
Roy William Burpee, Pittsburgh, Pa.
William Hector Bush, St. Louis, Mo.
Eugene Couch, Dallas, Tex.
William Slade Earle, Tallahassee, Fla.
Traugott Francis Keller, New York City
Charles Cyrus Kerns, Kansas City, Mo.
Robert Graham Lose, Atlanta, Ga.
Alva J. Smith, Emporia, Kans.

As Associate Members

Walter Francis Adams, Berkeley, Calif.
William George Alexander Adams, Inkster, Mich.
John David Anderson, New York City
Frederick Amerman Dale, Port Washington, N. Y.
Roy Harold Davis, Chicago, Ill.
Leslie Mortimer Dennis, Red Bank, N. J.
Frederick William Douglas, New York City
Fred George Fellows, Denver, Colo.
Albert Edwin Firmin, Comanche, Tex.
Robert Raymond Fisher, Fresno, Cal.
Harold Robert Leslie Fox, Kingston, Jamaica
Isidro Gabino Jáuregui, Santiago de Cuba, Cuba
James Kearney, New York City
Samuel Clair McKee, Toledo, Ohio
Warner John O'Leary, San Francisco, Calif.
George Edwin Oliver, Onawa, Iowa
Milan Kenton Orr, Harrison, Ark.
Joseph Guy Rollins, Breckenridge, Tex.
Charles Millichamp Romanowitz, Alameda, Calif.
Walter Clair Russell, Flint, Mich.
Otto Stephen Schlich, New York City
Harry Lawrence Shoemaker, Elizabeth, N. J.
John Perry Shumaker, Lima, Ohio
Earl Milton Spencer, Topeka, Kans.
John Joseph Sweeney, Philadelphia, Pa.

Frank Frederick Trierweiler, Portland, Ore.
Fritz Leroy Washburn, Decatur, Ill.
Laurence Edwin Whitaker, Flint, Mich.
William Guy Williams, New York City
Paul Eugene Wylie, Des Moines, Iowa

As Affiliates

Dwight Allen Grant, Oil City, Pa.

As Juniors

Charles Francis Balph, Ponca City, Okla.
Harrison Blankstein, New York City
Herbert Conrad DeStaebler, St. Louis, Mo.
Kenneth Louis Greeman, Indianapolis, Ind.
Ray Elliott Mackenzie, St. Ignatius, Mont.
William Edward Marshall, Ambridge, Pa.
Irving Holman Parker, Montreal, Que., Canada
John Macklem Perkins, Langhorne, Pa.
Walter Harrison Robertson, East Orange, N. J.

From Associate Member to Member

Eugene Duston Barstow, Akron, Ohio
Robert Wesley Briggs, Yonkers, N. Y.
Robert Lee Burney, San Antonio, Tex.
Harry Cady Byrnes, Pueblo, Colo.
John Hirst Caton, 3d, Santo Domingo, Dominican Republic
Robert Andrew Caughey, Ames, Iowa
Emerson Lawrence Chandler, Dayton, Ohio
Perley Eugene Conner, Winnetka, Ill.
George Washington Corrigan, Pasadena, Calif.
Waldo Scarlette Coulter, Brooklyn, N. Y.
Frank Oliver Dufour, Easton, Pa.
Harold Mansfield Eddy, Lakehurst, N. J.
Walter Linder Foster, Ames, Iowa
Joseph Harrington Gandolfo, Trenton, N. J.
Ward Hall, San Francisco, Calif.
John Thomas Hopkins, New Brunswick, N. J.
Louis Richard Hawson, La Grange, Ill.
Henry Louis Jacques, San Fernando, Calif.
Joseph Warren Jones, Dallas, Tex.
Percy Francis Jones, Modesto, Calif.
William Kelly, Washington, D. C.
Karl Raymond Kennison, Boston, Mass.
William Arthur Lafler, Rochester, N. Y.
Charles Walter Lawrence, Los Angeles, Calif.
Harry Fontaine McFarland, Jr., Wichita Falls, Tex.
Roger Leroy Morrison, Birmingham, Ala.

George Alexander Noren, New York City
Stephen Henley Noyes, Philadelphia, Pa.
Charles Wesley Petit, Ventura, Calif.
Herbert Fulwiler Robinson, Albuquerque, N. Mex.
Ralph Earle Rohn, Canton, Ohio
Willis Appleford Slater, Washington, D. C.
Claiborne Ellis Smith, East San Diego, Calif.
Walter Dorr Smith, Los Angeles, Calif.
John Rodgers Spelman, Rockville Centre, N. Y.
Gustavus William Thompson, Syracuse, N. Y.
Ernest Judson Waugh, Riverside, Calif.
Ellwood Coggeshall Wilder, Honolulu, Hawaii

From Affiliate to Member

Edward Cartwright Constance, Kansas City, Mo.

From Junior to Member

Solomon Jacob Harwi, Bayonne, N. J.

From Junior to Associate Member

Bjarne Bergsland Anderson, New York City
Raymond Fielding Braly, Spring Lake, N. J.
Robert Morris Copeland, Washington, D. C.
William Moragne Husson, New York City
Albertis Montgomery, Fort Sam Houston, Tex.
Henry Mitchel Weitzner, New York City

I also announce the following deaths:

Anderson Harvey Tyson, of New York City, elected Member, October 2d, 1889; died January 12th, 1922.

DeBerniere Whitaker, of Santiago de Cuba, Cuba, elected Member, October 1st, 1912; died December 25th, 1921.

Harold Ingersoll Bell, of Portland, Me., elected Associate Member, August 31st, 1915; died December 28th, 1921.

Anson Morse Blenus, of North Pelham, N. Y., elected Associate Member, July 6th, 1920; died January 5th, 1922.

Clifford Marshall King, of Cleveland, Ohio, elected Junior, March 6th, 1906; Associate Member, July 1st, 1909; died January 2d, 1922.

Abraham John Ruth, of Tampico, Mexico, elected Associate Member, March 4th, 1913; died November 3d, 1921.

Edmund Abiel Thornton, of Ray, Ariz., elected Associate Member, November 4th, 1914; died January 9th, 1922.

The President.—At this time are there any reports from the Board of Direction? There is none in the hands of the Acting Secretary.

The Acting Secretary.—I wish to announce that the organization meeting of the new Board of Direction will be held in the Board Room at 4 p. m., this afternoon. Your attention is also directed to a new type of "name plate", so to speak, which is relatively expensive. The plan is that at the last

meeting which you attend, you will leave the badge in a receptacle at the door, so that it may be used again year after year. I hope you will co-operate in carrying out this plan. There are no further announcements.

THE PRESIDENT.—New business is in order. Have you any new business?

THE ACTING SECRETARY.—No.

THE PRESIDENT.—Has any member any new business? There being no new business the report of the Tellers is in order, the report of the canvass for officers, William G. Grove, Chairman of the Committee.

WILLIAM G. GROVE, M. AM. SOC. C. E.—The report of the Tellers is as follows:

"33 WEST 39TH STREET, NEW YORK, N. Y.,
"January 18th, 1922.

"TO THE SIXTY-NINTH ANNUAL MEETING,
AMERICAN SOCIETY OF CIVIL ENGINEERS:

"The Tellers appointed to canvass the ballots for Officers of the Society for 1922, report as follows:

"Total number of ballots received		2152
"Deduct		
"Ballots from members in arrears of dues	9	
" with lettered instead of written signature	4	
" unsigned	23	
"Total number not entitled to vote		36
"Ballots canvassed		2116

"For President:

JOHN RIPLEY FREEMAN	2097
Scattering	9

"For Vice-Presidents:

CARL EWALD GRUNSKY	2081
ROBERT RIDGWAY	2069
Scattering	11

"For Directors:

District No. 1	CLIFFORD M. HOLLAND	2034
	JOSEPH JOHNSON YATES	2042
	Scattering	6
District No. 2	FRANK EDWARD WINSOR	2029
	Scattering	3
District No. 6	JOHN NEEDELS CHESTER	2016
	Scattering	13
District No. 8	ARTHUR JAMES DYER	2023
	Scattering	9
District No. 13	WALTER LEROY HUBER	2036
	Scattering	3

"W. G. GROVE, *Chairman,*

"C. S. BILYEU,
A. W. CARPENTER,
RALPH H. CHAMBERS,
C. E. CONOVER,
R. DE CHARMS,
MYRON E. FULLER,

"R. R. GRAHAM,
H. P. HAMMOND,
GEORGE PERRINE,
F. W. PERRY,
D. H. SAWYER,
GEORGE L. SAWYER,

Tellers."

(The President announced the election of the Members having the highest votes for the respective offices.)

The President.—I will appoint Past-Presidents Davis and Talbot to escort the newly elected President to the chair.

John R. Freeman, President, Am. Soc. C. E.—Mr. President and Fellow Members: It goes without saying that I deeply appreciate this high honor. I have been a member in one grade and another for about forty years. I began as a Junior, and I think the greatest benefit I received from this Society was during my days as a Junior, from the inspiration I got from the older men. I approach this office with great humility, after I recall the Past-Presidents whom I have known, and I realize that my own powers are relatively limited. I am only one member of the Board of Direction.

I wish you could all have been present last evening at the meeting of the past and present officers of this Society, or that you could at least have heard the general tenor of the remarks. There was not a discordant note of any kind. All the speech-making was directed toward the future progress of the Society, and it all centered around three main topics: How can the Society be made of greater service to the distant members; how can we advance the Society by Local Sections; and, what can be done for the benefit of Student Chapters and the Juniors?

I have been profoundly impressed this morning with the possibilities of usefulness in the American Society of Civil Engineers, as I have listened to the reports of the activities during the past year. It seems to me that the titles of more than a dozen Committee Reports that were placed before you should satisfy the most progressive members; that the most conservative member will not be afraid of any action that will injure the fair fame of this Society, while its destiny is looked after by the present membership of the Board of Direction.

For myself and for my fellow members of the Board of Direction, I can assure you that we all have our faces turned toward the sunrise and that we will serve you to the very best of our ability. I thank you.

The Acting Secretary has an announcement to make.

The Acting Secretary.—Mr. President, a very extensive effort has been made to secure reduced fare for the members who are obliged to come from a long distance. Those who have Certificates are requested to be sure to have them validated before going to the luncheon at the McGraw-Hill Building. The members are also reminded that immediately on the adjournment of this meeting, they will find buses ready on Thirty-ninth Street to transport them as quickly as possible to the McGraw-Hill Building. I thank you.

The President.—Is there anything further to come before this meeting? If not, I will declare the meeting adjourned.

January 19th, 1922.—The meeting was called to order at 9.30 a. m., by President John R. Freeman; Elbert M. Chandler, Acting Secretary; and present, also, 105 members and guests.

Owing to a meeting of the Board of Direction, President Freeman placed the meeting in charge of Vice-President C. E. Grunsky.

The subject for this meeting was "Water Transportation",* discussion on which was opened by R. H. M. Robinson, Acting President, United American Lines, Incorporated, New York City. Mr. Robinson was followed by Winthrop L. Marvin, Vice-President and General Manager, American Steamship Owners' Association, New York City, who spoke briefly relative to the "American Merchant Marine." This subject was also discussed, from the standpoint of the economist, by Dr. Emory R. Johnson, Dean, Wharton School of Finance and Economy, University of Pennsylvania, Philadelphia, Pa. Samuel O. Dunn, Editor of *Railway Age,* Chicago, Ill., who followed Dr. Johnson, discussed "Water Transportation in Its Relation to the Railways".

The addresses were followed by discussion of the general subject by Messrs. J. E. Willoughby, J. C. Trautwine, Jr., Gardner S. Williams, Augustus Smith, W. F. Rittman, C. C. Vermeule, and Benjamin F. Groat.

Adjourned at 12 M., to meet again at 2.10 P. M.

January 19th, 1922.—The meeting was called to order at 2.10 P. M.; Past-President F. S. Curtis in the chair; and present, also, 277 members and guests.

The afternoon session was devoted to a discussion of "Railroad Transportation".† The first speaker was Howard Elliott, Affiliate, Am. Soc. C. E., Chairman, Executive Committee, Northern Pacific Railway Company, New York City. Mr. Elliott was followed by William N. Doak, Vice-President, Brotherhood of Railroad Trainmen, Washington, D. C., and F. A. Molitor, M. Am. Soc. C. E., Chairman, Board of Economics and Engineering, National Association of Owners' of Railroad Securities, New York City.

Adjourned at 4.15 P. M., to meet again at 9.40 A. M., on January 20th, 1922.

January 19th, 1922.—The meeting was called to order at 8.30 P. M.; President John R. Freeman in the chair; and present, also, about 1 000 members and guests.

President Freeman introduced the speaker of the evening, Mr. Frank A. Vanderlip, of New York City, who addressed the meeting on "World Activities and Their Effect Upon the Engineer".‡

At the conclusion of his interesting address, Mr. Vanderlip was tendered a rising vote of thanks.

January 20th, 1922.—The meeting was called to order at 9.40 A. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 123 members and guests.

This session, the first of three at which "Highway Transportation" was discussed, was devoted to "Inspection of Highway Work".§ The first speaker, Thomas H. MacDonald, Director, U. S. Bureau of Public Roads, Washington, D. C., analyzed briefly the status of highway improvement as it is to-day.

(Past-President Clemens Herschel took the chair.)

* See Papers and Discussions, p. 265.

† *Ibid,* p. 287.

‡ See p. 140.

§ See Papers and Discussions, p. 318.

The next speaker, H. E. Hilts, Assoc. M. Am. Soc. C. E., Principal Assistant Engineer, Pennsylvania State Highway Department, Harrisburg, Pa., described briefly the highway work being done in Pennsylvania. Mr. Hilts was followed by William G. B. Thompson, Assoc. M. Am. Soc. C. E., formerly State Highway Engineer of New Jersey, Trenton, N. J., whose subject was "Highway Inspection".

The addresses were followed by a discussion of the general subject by Messrs. T. Hugh Boorman, Samuel Whinery, John C. Trautwine, Jr., E. W. Stern, Henry Goldmark, M. S. Ketchum, and H. W. Brown.

Adjourned at 12.30 P. M., to meet again at 2.15 P. M.

January 20th, 1922.—The meeting was called to order at 2.15 P. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 154 members and guests.

In continuation of the discussion on "Highway Transportation", the afternoon session was devoted to the question of "Financing and Bonding for Highway Construction".* The discussion was opened by John N. Cole, Commissioner, State Department of Public Works, Boston, Mass., who was followed by the Hon. Francis M. Hugo, formerly Secretary of State of New York, who presented a paper on the subject by E. A. St. John, Vice-President, National Surety Company, New York City. Mr. Hugo was followed by Edward C. Lunt, Vice-President, Fidelity and Casualty Company, New York City, who discussed the "Underwriting of Highway Bonds", and Harry Meixell, Jr., Secretary, Motor Vehicle Conference Committee, New York City. The subject was also discussed by Frederick Stuart Greene, M. Am. Soc. C. E., formerly State Commissioner of Highways of New York City, and Herbert S. Sisson, State Commissioner of Highways, Albany, N. Y.

Adjourned at 4.25 P. M., to meet again at 8.15 P. M.

January 20th, 1922.—The meeting was called to order at 8.15 P. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 59 members and guests.

The evening session was devoted to a continuation of the discussion on "Highway Transportation". The subjects discussed were "Administration", "Relation of Highway to Other Transportation Systems", and "Motor Vehicle Control".†

In the absence of Robert S. Parsons, M. Am. Soc. C. E., General Manager, Erie Railroad Company, New York City, the Acting Secretary presented his paper on "The Motor Truck as an Asset to Railroad Operation". G. Wythe Munford, Inspector, Commission of Motor Vehicles, Baltimore, Md., addressed the meeting on "The Control of Motor Vehicle Traffic as We Handle It in Maryland", and the question of "State Regulation of Motor Transportation" was discussed by Mr. Harry Meixell, Jr.

Adjourned.

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* See Papers and Discussions, p. 236.

† *Ibid*, p. 345.

February 1st, 1922.—The meeting was called to order at 8:20 P. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 135 members and guests.

The minutes of the meetings of January 4th and 5th, 1922, were approved as printed in *Proceedings* for January, 1922.

The Acting Secretary announced the following deaths:

HARRY KENT SELTZER, of Kansas City, Mo., elected Junior, February 4th, 1896; Associate Member, January 2d, 1901; Member, April 3d, 1906; died December 30th, 1921.

CHARLES ALBERT LORING WRIGHT, of Springfield, Mass., elected Member, October 10th, 1916; died August 17th, 1921.

The meeting was devoted to a lecture on "Past and Predicted Growth of Power Demand in New York State" by John P. Hogan, M. Am. Soc. C. E., who illustrated his remarks with lantern slides. The subject was also discussed by President Freeman and Messrs. T. Kennard Thomson and H. de B. Parsons.

Adjourned.

EXCURSIONS AND ENTERTAINMENTS AT THE SIXTY-NINTH ANNUAL MEETING

Wednesday, January 18th, 1922.—At the close of the Business Meeting of the Society at 1 P. M., about 600 members were taken in buses to the plant of the McGraw-Hill Publishing Company, at Tenth Avenue and 36th Street. Through the courtesy of E. J. Mehren, Affiliate, Am. Soc. C. E., Editor, *Engineering News-Record,* the members were guests at a luncheon served in the plant. After the luncheon, the visitors were divided into small parties and conducted on an inspection tour of the establishment which lasted all afternoon. A pamphlet was distributed in which was described the points of interest. Special exhibits had been arranged, and a most interesting and instructive visit was enjoyed by the members.

At 7.30 P. M., a Dinner Dance and Reception in honor of the President and the newly elected Honorary Members of the Society, was held in the Hotel Pennsylvania, at which there were present about 400 members and guests. The Dinner Dance was an innovation, but proved to be unusually enjoyable.

Thursday, January 19th, 1922.—In accordance with plans made by the Local Committee on Arrangements, the members were offered two trips to places of interest in the city.

Trip No. 1.—From 9.00 A. M. until noon, guides conducted members in small groups to the New York Stock Exchange. About 550 members took advantage of this interesting excursion and were able to view the Exchange in operation. After leaving the Exchange the parties were conducted to the foundation work of the new $15 000 000 Federal Reserve Bank Building at Nassau and Liberty Streets. At 1.00 P. M., luncheon was served in the Engineering Societies Building.

Trip No. 2.—At 2.00 P. M., buses conducted about 400 members and guests to the Hell Gate Power Station of the United Electric Light and Power Company at East River and 135th Street. This plant, when completed, will have an ultimate capacity of 240 000 kw.

At 8.30 P. M., in the Auditorium of the Engineering Societies Building, Mr. Frank A. Vanderlip, formerly President of the National City Bank of New York City, delivered an interesting address on "World Activities and Their Effect Upon the Engineer". About 1 000 members and guests were present, and following the address an informal Smoker and social was held on the Fifth Floor.

The following list contains the names of 953 members of various grades who registered as being in attendance at the Annual Meeting. The list is probably incomplete, as some members failed to register, and it does not contain the names of any of the guests of the Society or of individual members. It is estimated that the total attendance was about 1 200.

Attendance at Annual Meeting

Abbott, H. . . . . New York City
Ackerman, A. P. . . . . New York City
Adams, E. G. . . . . New York City
Adey, W. H. . . . . Cohoes, N. Y.

Aiken, W. A.....Mamaroneck, N. Y.
Aikenhead, J. R...Rutherford, N. J.
Albertson, J. J......Magnolia, N. J.
Alexander, A.........New York City
Alderson, A. B..West Hartford, Conn.
Allee, D. A......Schenectady, N. Y.
Allen, E. Y.........Philadelphia, Pa.
Allen, F. W.......Mt. Vernon, N. Y.
Allen, H. D..........Newark, N. J.
Allen, K............New York City
Alvord, J. W...........Chicago, Ill.
Ammann, O. H......New York City
Anderberg, E........New York City
Anderson, B. B......New York City
Anderson, G. G...Los Angeles, Calif.
Andrews, H..........Albany, N. Y.
Archer, A. R........New York City
Armstrong, R. W....Brooklyn, N. Y.
Ash, W. J............Newark, N. J.
Atkinson, A...New Brunswick, N. J.
Auryansen, F........Jamaica, N. Y.
Austin, H. S........Elizabeth, N. J.
Austin, W. E........New York City
Aylett, P..............Hollis, N. Y.

Babcock, W. S.......New York City
Baird, H. C.........New York City
Baker, F. A.......Allenhurst, N. J.
Baker, I. O.............Urbana, Ill.
Baldwin, A. S..........Chicago, Ill.
Baldwin, W. J.......New York City
Ball, L. A...........New York City
Bamford, W. B........Belmar, N. J.
Banta, R. V.........New York City
Baptiste, E. E.....Jersey City, N. J.
Barbour, F. A........Boston, Mass.
Barck, W. F........Hoboken, N. J.
Barnes, F. E........New York City
Barnes, O. F.....Jersey City, N. J.
Barnes, T. H........New York City
Barnes, W. T......Wilkes-Barre, Pa.
Barney, P. C........New York City
Barney, S. E.....New Haven, Conn.
Bassett, W. A.......New York City
Batchelder, B. F.....Boonton, N. J.
Bayles, G. H...Morgantown, W. Va.
Beam, C. E.........New York City
Bean, E. D......Schenectady, N. Y.
Beer, F. M..........Brooklyn, N. Y.
Beggs, G. E........Princeton, N. J.
Begien, R. N......Cincinnati, Ohio
Belcher, W. E........New York City
Belden, E. T......Englewood, N. J.
Belknap, J. M.......New York City
Bell, J. C..........Elmhurst, N. Y.
Bellows, O. F........New York City
Belzner, T..........Brooklyn, N. Y.
Benedict, F. N...East Orange, N. J.
Bennett, H..........New York City
Bennett, J. W. F.....New York City
Bensel, J. A.........New York City
Berger, J............New York City
Berry, H. C.......Philadelphia, Pa.
Besselievre, E. B.....New York City
Beswick, J. E...New Brighton, N. Y.
Bettes, C. R...Far Rockaway, N. Y.
Beugler, E. J........New York City
Bevan, L. J.........New York City
Bilyeu, C. S.........New York City
Binger, W. D........New York City
Bissell, C. T.........New York City
Blair, A...........Millington, N. J.
Blakeslee, C......New Haven, Conn.
Blanchard, R. K.....New York City
Blech, E. S......New Rochelle, N. Y.
Boardman, C. S.....Buffalo, N. Y.
Boardman, H. E.....New York City
Boetzkes, H. W......New York City
Bogardus, J. S....Mt. Vernon, Ohio
Bogart, J. L.......Glen Head, N. Y.
Bogert, C. L..........Teaneck, N. J.
Boland, C. J............Troy, N. Y.
Boller, A. P., Jr...East Orange, N. J.
Bolmer, M. T..Richmond Hill, N. Y.
Bond, E. A...........Castleton, Pa.
Bond, G. M........Hartford, Conn.
Boniface, A........Scarsdale, N. Y.
Bontecou, D.....Mamaroneck, N. Y.
Boorman, K. M......New York City
Booth, G. W.........New York City
Borough, E. W.......New York City
Boucher, W. J.......New York City
Boyden, H. C..........Chicago, Ill.
Brackenridge, J. C...New York City

Bradley, F. E........New York City
Braunworth, P. L.....Newark, N. J.
Breed, C. B...........Boston, Mass.
Breitzke, C. F........Boonton, N. J.
Brennan, E. M........Albany, N. Y.
Brennan, J. L.......New York City
Breuchaud, J........New York City
Briggs, J. A.........New York City
Briggs, R. W........Yonkers, N. Y.
Brodie, O. L.........New York City
Brosius, A. M........Baltimore, Md.
Brown, A. T.........New York City
Brown, B. L..........St. Louis, Mo.
Brown, H. W..........Boston, Mass.
Brown, L. F........Brooklyn, N. Y.
Brown, S. D.........New York City
Brown, T. E.........New York City
Brumley, D. J..........Chicago, Ill.
Brush, W. W.........New York City
Bryan, C. W.........New York City
Buck, H. R.........Hartford, Conn.
Buck, R. S..........New York City
Buel, A. W..........New York City
Buettner, O. G. H....New York City
Burdett, F. A........New York City
Burpee, G. W........New York City
Burr, W. H..........New York City
Burroughs, H. R.....New York City
Bush, E. W.........Hartford, Conn.
Bush, Lincoln........New York City

Cadwallader, W. L...New York City
Calvert, L. L........New York City
Campbell, C. C.....Philadelphia, Pa.
Carlile, T. J.........Jamaica, N. Y.
Carmalt, L. J....New Haven, Conn.
Carpenter, A. W......Yonkers, N. Y.
Carr, A..........East Orange, N. J.
Carstarphen, F. C.....Trenton, N. J.
Casani, A. A.........New York City
Case, M. B.........Philadelphia, Pa.
Casler, M. D.....Mt. Vernon, N. Y.
Castillo y Grau, A..Cienfuegos, Cuba
Castleman, F. L........Pencoyd, Pa.
Chadwick, C. H......New York City
Chandler, E. M......New York City
Chapman, A. G.......Albany, N. Y.
Chase, C. E.......Philadelphia, Pa.
Chase, C. F......New Britain, Conn.
Chase, J. C.....Derry Village, N. H.
Chester, J. N........Pittsburgh, Pa.
Chorlton, W. H......New York City
Cilley, M............New York City
Clapp, S. K.....Grand Gorge, N. Y.
Clark, A. E..........New York City
Clark, F. J......Dobbs Ferry, N. Y.
Clark, G. H..........New York City
Clarke, E. W........Baltimore, Md.
Clarke, St. J..........Bogota, N. J.
Codwise, H. R......Brooklyn, N. Y.
Coe, D. W.......Pearl River, N. Y.
Coffin, F. D. L......Katonah, N. Y.
Coffin, W. C.........New York City
Cohen, A. B..........Newark, N. J.
Cole, E. S...........New York City
Collins, C. D........New York City
Collins, R. G......Cumberland, Md.
Collyer, N...........New York City
Conard, W. R.....Burlington, N. J.
Conard, W. W.......Norristown, Pa.
Conger, R. A.......Worcester, Mass.
Conley, W. A........New York City
Connelly, J. A. A....New York City
Conover, C. E.......New York City
Constable, H........Kingston, Mass.
Cook, J. H..........Paterson, N. J.
Coombs, A. W.......New York City
Coombs, S. E........New York City
Corkran, W. S...East Orange, N. J.
Cornell, G. B........Yonkers, N. Y.
Covert, C. C..........Albany, N. Y.
Crane, A. S..........New York City
Craigmile, C. J.....Wanague, N. J.
Craven, A. S.......Philadelphia, Pa.
Cresson, B. F., Jr....New York City
Creuzbaur, R. W....New York City
Critchlow, H. T......Trenton, N. J.
Crooks, C. H.........New York City
Crosby, H.........Maplewood, N. J.
Cross, W. C.........Brooklyn, N. Y.
Crowell, F. S........New York City
Cuddeback, A. W.....Paterson, N. J.
Cudworth, F. E.....Brooklyn, N. Y.
Cullen, J. F.......Philadelphia, Pa.

Culyer, T. C.........New York City
Cummings, N.....Mt. Vernon, N. Y.
Cummings, R. A.....Pittsburgh, Pa.
Curtis, F. S...........Boston, Mass.
Cushing, W. C.....Philadelphia, Pa.
Cutler, L. G...........Nutley, N. J.

Dahm, S............New York City
Daino, A. J.........New York City
Dakin, A. H., Jr.....New York City
Dalstrom, O. F........Chicago, Ill.
Daly, J. W.....New Rochelle, N. Y.
Dana, A...........Philadelphia, Pa.
Danforth, G. C........Augusta, Me.
Darrow, F. T........Lincoln, Nebr.
Davies, J. V.........New York City
Davis, A. P......Washington, D. C.
Davis, B. H..........New York City
Davis, C.............New York City
Davis, F. A. W.......New York City
Davis, J. L..........Montpelier, Vt.
Davis, L. H..........New York City
Dawley, W. M.......New York City
Day, C. I...............Troy, N. Y.
Day, E. B...........New York City
Deakman, H. W.....Brooklyn, N. Y.
de Charms, R., Jr...Westfield, N. J.
Deiser, N. A........Brooklyn, N. Y.
Delson, I............New York City
de Moll, C.........Philadelphia, Pa.
Denise, C. M........Pittsburgh, Pa.
Dennett, R. C........New York City
De Schauensee, F....New York City
Develin, R. G......Philadelphia, Pa.
Devlin, H. S.........Brooklyn, N. Y.
De Witt, P. H........Newark, N. J.
Deyo, S. L. F........New York City
Diamant, A. H.......New York City
Dickerson, O. H......Duluth, Minn.
Digby, J. H.........Brooklyn, N. Y.
Dimon, D. Y......Riverhead, N. Y.
Dingman, C. F.......Palmer, Mass.
Disbrow, C. A.......New York City
Dittman, W. A.......Yonkers, N. Y.
Diven, J. M.........New York City
Dixon, G. G............Akron, Ohio
Donnelly, A. L...New Haven, Conn.
Dorrance, W. T...New Haven, Conn.
Doten, L. S.......Washington, D. C.
Dougherty, R. E.....New York City
Dresser, G. L.........Albany, N. Y.
Drew, C. D..........New York City
Drummond, W. W.,
Fort H. G. Wright, N. Y.
Dudley, F. L.........Ambridge, Pa.
Dufour, F. O............Easton, Pa.
Dunham, H. F......New York City
Durant, A.............Boston, Mass.
Durfee, J. J........Pavillion, N. Y.
Durham, L......Pleasantville, N. Y.
Dutton, C. H......Providence, R. I.
Dyer, A. J.........Nashville, Tenn.
Dykeman, C. F......Brooklyn, N. Y.

Earle, T.............Bethlehem, Pa.
Eddy, H. P....Newton Center, Mass.
Eden, A. W. A...East Orange, N. J.
Edwards, D. G.......Jamaica, N. Y.
Edwards, J. H.......New York City
Ehle, Boyd........East Creek, N. Y.
Eide, Torris.........New York City
Elkins, S. S........Brooklyn, N. Y.
Elliott, H...........New York City
Endemann, H. K.....New York City
Epple, E. C........Bloomfield, N. J.
Estes, A. D..........New York City
Evers, R............New York City

Fairchild, J. F.......Pelham, N. Y.
Fajardo, J............Cali, Colombia
Falk, M. S...........New York City
Farley, J. M....White Plains, N. Y.
Farrington, H.....Middleboro, Mass.
Farrington, H. P....New York City
Fay, F. H............Boston, Mass.
Fenkell, G. H.........Detroit, Mich.
Files, T. H..........New York City
Finch, J. K.........New York City
Finebaum, H. J......Bethlehem, Pa.
Fisher, E. A........Rochester, N. Y.
Fletcher, R..........Hanover, N. H.
Flinn, A. D..........New York City
Fogg, R. J..........Bethlehem, Pa.
Forbes, F. B.........New York City

Forgie, J............New York City
Foster, E. H....Dongan Hills, N. Y.
Fougner, H..........New York City
Frank, A. H........Brooklyn, N. Y.
Freeman, A. C., Jr..Philadelphia, Pa.
Freeman, J. R.....Providence, R. I.
Freeman, W. B........Denver, Colo.
French, A. W......Worcester, Mass.
French, H...........New York City
French, J. B.........New York City
Frisby, E. R.....Washington, D. C.
Fuller, G. W........New York City
Fuller, M. E.........New York City

Gallogly, A. V.......Yonkers, N. Y.
Gardiner, F. W......New York City
Gardiner, J. B. W....New York City
Gardner, H. C........Lancaster, Pa.
Gardner, W.........New York City
Garfias, V. R.........New York City
Gaston, L. P......Somerville, N. J.
Gates, H. B........Mt. Kisco, N. Y.
Gausmann, R. W.....Albany, N. Y.
Gaylord, L. T......Montclair, N. J.
Gemberling, J. B...Philadelphia, Pa.
Gendell, D. S., Jr.....Pottstown, Pa.
George, H. H.........Newark, N. J.
Gibbs, G............New York City
Gifford, G. E........New York City
Gildersleeve, A. C....New York City
Gildersleeve, G. S....New York City
Giles, J. A......Binghamton, N. Y.
Gilman, C...........New York City
Gilmore, T. N.......New York City
Givotovsky, V. T.....New York City
Glander, J. H., Jr..Glen Ridge, N. J.
Goldmark, H.........New York City
Goldsborough, J. B...New York City
Goldsmith, W........New York City
Goodell, J. M........Montclair, N. J.
Goodkind, M..New Brunswick, N. J.
Goodman, J.........New York City
Goodrich, E. P......Brooklyn, N. Y.
Goriachkovsky, V....New York City
Gould, R. R.........New York City
Gould, W. T........Hastings, N. Y.
Graham, G. A......Brooklyn, N. Y.
Graham, R. R.......Yonkers, N. Y.
Granbery, J. H.......Paris, France
Gray, H. M.........Katonah, N. Y.
Gray, W.............New York City
Green, B. L.........Cleveland, Ohio
Greene, C............New York City
Greenhalgh, S. F......Avenel, N. J.
Greenlaw, R. W.....New York City
Gregory, A. C........Trenton, N. J.
Gregg, T. D..........Newark, N. J.
Greiner, J. E.........Baltimore, Md.
Griggs, T. G........Hoboken, N. J.
Groat, B. F.........Pittsburgh, Pa.
Gross, C. F........Philadelphia, Pa.
Grove, W. G.........New York City
Grover, W. A..........Dover, N. H.
Grunsky, C. E..San Francisco, Calif.
Gunther, C. O.......Hoboken, N. J.

Hager, A. B.......Rutherford, N. J.
Haggard, H. H...Hackensack, N. J.
Haines, E. G.........New York City
Hale, H. E..........New York City
Hale, R. A..........Lawrence, Mass.
Hall, M. W..........New York City
Hall, W. H......New Britain, Conn.
Halmos, E. E........New York City
Halsey, W. H...Southampton, N. Y.
Hamilton, E. P......New York City
Hamilton, John W...New York City
Hammond, H. P....Brooklyn, N. Y.
Hanavan, W. L.......Tenafly, N. J.
Hansel, C...........New York City
Harby, I.............New York City
Hardesty, S..........New York City
Harding, H. S..Pelham Manor, N. Y.
Harris, H. F.........Trenton, N. J.
Harrison, B. J......Brooklyn, N. Y.
Harrison, G..........New York City
Harte, C. R......New Haven, Conn.
Hartwell, O. W.......Trenton, N. J.
Harwi, S. J..........Bayonne, N. J.
Haskins, W. J.......New York City
Hatton, T. C.......Milwaukee, Wis.
Hauck, W...........New York City
Havens, V. L........New York City
Haydock, C........Philadelphia, Pa.

Hazen, A. . . . . New York City
Heller, J. W. . . South Orange, N. J.
Helling, H. A. North Tarrytown, N. Y.
Hellyer, H. A. C. . . . . . Tenafly, N. J.
Henckel, A. H. . . . . Maplewood, N. J.
Henderson, A. R. . . Jersey City, N. J.
Hennebique, J. J. . . . . New York City
Henny, D. C. . . . . Portland, Ore.
Henry, P. W. . . . . New York City
Herschel, Clemens. . . . New York City
Heslop, P. L. . . . . . . Philadelphia, Pa.
Hewes, V. H. . . . . New York City
Higgins, C. H. . . . . . . New York City
Higgins, J. W. . . Roselle Park, N. J.
Hill, H. C. . . . . . . Binghamton, N. Y.
Hilpert, M. G. . . . . Bethlehem, Pa.
Hilts, H. E. . . . . Harrisburg, Pa.
Hirst, A. . . . . New York City
Hoadley, R. B., Jr. . Binghamton, N. Y.
Hobbs, H. W. . . . . New York City
Hodgdon, B. A. . . . . . . New York City
Hodgman, B. B. . . . . . New York City
Hogan, J. P. . . . . New York City
Holden, C. A. . . . . New York City
Holden, C. A. . . . . Hanover, N. H.
Holdredge, N. C. . . . . . Haskell, N. J.
Holland, C. M. . . . . . . New York City
Hollyday, R. C. . . . . Brooklyn, N. Y.
Holtzman, S. F. . . . . . Hastings, N. Y.
Honness, G. G. . . Grand Gorge, N. Y.
Hood, B. O. . . . . Newark, N. J.
Hooper, E. G. . . . . New York City
Hoover, A. P. . . . . New York City
Hopson, E. G. . . . . Portland, Ore.
Horne, H. W. . . . . Belmont, Mass.
Horton, R. E. . . . . Albany, N. Y.
Hough, D. L. . . . . New York City
Howard, J. L. . . . . Boston, Mass.
Howe, W. C. . . . . Worcester, Mass.
Howes, D. W. . . . . New York City
Howes, B. A. . . . . New York City
Howson, E. T. . . . . Chicago, Ill.
Hoyt, J. C. . . . . . . Washington, D. C.
Huber, W. L. . . San Francisco, Calif.
Hudson, C. W. . . . . . . New York City
Hughes, H. J. . . . . . Cambridge, Mass.
Hulburd, L. S. . . . . Albany, N. Y.
Hulsart, C. R. . . . . New York City
Humphrey, Richard L., Philadelphia, Pa.
Hunt, C. A. . . . . Brooklyn, N. Y.
Hunt, C. E. . . . . New York City
Hunt, R. W. . . . . Boonton, N. J.
Hurd, H. L. . . . . New York City
Hurlbut, C. C. . . . . New York City
Hurlbut, H. B. . . . . . Montclair, N. J.
Hutchins, E. . . . . New York City
Hyatt, C. . . . . New York City
Hyde, H. E. . . . . Ithaca, N. Y.
Hyman, A. D. . . . . New York City
Hyman, H. A. . . . . . Woodmere, N. Y.

Ingersoll, C. M. . . . . . New York City
Irwin, J. C. . . . . Boston, Mass.

Jackson, J. F. . . . . New Haven, Conn.
Jackson, W. B. . . . . . . Pittsfield, Mass.
Jacobsen, H. R. . . . . . Brooklyn, N. Y.
James, F. T. . . . . . . Cambridge, Mass.
Joachimson, M. . . . . . . New York City
Johnson, G. A. . . . . . . New York City
Johnston, J. A. . . . . . Worcester, Mass.
Johnston, J. H. . . . . Atlanta, Ga.
Johnston, J. W. . . . . . . New York City
Johntz, A. F. . . . . Aberdeen, Md.
Jones, S. R. . . . . New York City
Junkersfeld, P. . . . . Boston, Mass.

Kahlert, E. D. . . . . Freeport, N. Y.
Kastl, A. E. . . . . Rutherford, N. J.
Kayser, E. M. . . . . New York City
Keefe, D. A. . . . . Athens, Pa.
Kehoe, A. L. . . . . New York City
Keith, H. C. . . . . New York City
Ketchum, M. S. . . . . Philadelphia, Pa.
Khuen, R., Jr. . . . . . . Pittsburgh, Pa.
Killmer, M. I. . . . . East Orange, N. J.
Killough, E. M. . . . . . . Baltimore, Md.
Kimball, F. C. . . . . Summit, N. J.
King, H. L. . . . . Brooklyn, N. Y.
Kinsey, W. A. . . . . Newark, N. J.
Kipp, B. . . . . New York City
Kirkwood, H. C. . . . . Flushing, N. Y.
Knight, H. M. . . . . . . Montclair, N. J.

Knight, R. W........New York City
Knight, S. H......Philadelphia, Pa.
Knighton, J. A.......New York City
Knox, S. B..........New York City
Kohlheyer, C. C......New York City
Kornfeld, A. E.......New York City
Kramer, W. D...Scarborough, N. Y.
Kraus, A...........Brooklyn, N. Y.
Krefeld, W. J.......New York City
Kuchar, F. M.......Montvale, N. J.
Kunesh, J. F........Brooklyn, N. Y.

Laboon, J. F........Pittsburgh, Pa.
Lamb, L. C....Cuyahoga Falls, Ohio
Lame, H. F..........New York City
Lamphere, F. E......New York City
Lamson, W. M......Brooklyn, N. Y.
Lanagan, F. R........Albany, N. Y.
Landreth, O. H......New York City
Lang, P. G., Jr.......Baltimore, Md.
Langthorn, J. S......New York City
Larsson, C. G. E.....Plainfield, N. J.
Latey, H. N.........New York City
Latta, H. W.......Philadelphia, Pa.
Laurson, P. G....New Haven, Conn.
Lawrence, E. V......New York City
Lawrence, R. J.....Philadelphia, Pa.
Lea, R. S....Montreal, Que., Canada
Leahy, T. E........Philadelphia, Pa.
Lee, W. B..........New York City
Leffler, B. R.........Cleveland, Ohio
Lehlbach, G..........Newark, N. J.
Lemberger, O........New York City
Leon, H. M.........Brooklyn, N. Y.
Lesley, R. W.......Philadelphia, Pa.
Lewis, H. M........Brooklyn, N. Y.
Lewis, L. H.........New York City
Lewis, N. P.........Brooklyn, N. Y.
Lex, W. I.........Philadelphia, Pa.
Lieb, J. W...........New York City
Lilliestrand, C. E....Pittsfield, Mass.
Lobo, C............Brooklyn, N. Y.
Lockwood, W. D....Philadelphia, Pa.
Loewenstein, J.......New York City
Logan, J........Mount Holly, N. J.
Look, F. W..........Paterson, N. J.
Look, M. J..............Hope, R. I.
Lovell, E. B..........New York City
Lowinson, O.........New York City
Lucas, G. L..........New York City
Lund, G. A.......Bridgeport, Conn.
Lundie, J...........New York City

MacCornack, C.....Phoenixville, Pa.
MacFecters, J. O..Glen Ridge, N. J.
MacGregor, R. A....New York City
Machen, H. B.......New York City
Macksey, H. V...Framingham, Mass.
McCarthy, D. F....Bronxville, N. Y.
McCollough, C. A....New York City
McComb, C. O........Adams, N. Y.
McComb, D. E....Washington, D. C.
McDougall, A. H........Harvey, Ill.
McDowell, F. F......Yonkers, N. Y.
McElroy, J. A.....Bridgeport, Conn.
McInnes, F. A........Boston, Mass.
McIntyre, W. A....Philadelphia, Pa.
McKean, A. M., Jr...Brooklyn, N. Y.
McLoud, P........Whiteboro, N. Y.
McMinn, T. J.....Bridgeport, Conn.
McNaughton, W. C.,
West Englewood, N. J.
McNeal, J..............Easton, Pa.
McPike, M. J.......Brooklyn, N. Y.
Main, C. T............Boston, Mass.
Mandell, S. B........New York City
Manley, H., Jr......Elmhurst, N. Y.
Manley, L. B......Philadelphia, Pa.
Marsden, R. R......Hanover, N. H.
Marshall, C. E. D..Garden City, N. Y.
Marshall, L. S.......New York City
Marshall, R. A.......New York City
Marston, A..............Ames, Iowa
Martin, E. S..Toronto, Ont., Canada
Massa, W. J...Port Richmond, N. Y.
Masters, F. M.......Harrisburg, Pa.
Matheson, J. D......Yonkers, N. Y.
Matlaw, I. S.........New York City
Mayell, A. J.........New York City
Mazeau, A...........New York City
Mazeau, C............Milford, Conn.
Mead, C. A...Upper Montclair, N. J.
Meadowcroft, W.....New York City
Mebus, C. F.......Philadelphia, Pa.

Mehren, E. J........New York City
Meigs, J...........Philadelphia, Pa.
Meise, G. J..........New York City
Melius, L. L.........New York City
Merriman, R. M......New York City
Merriman, T........New York City
Merryman, W. C.....New York City
Metcalf, L.............Boston, Mass.
Miller, A. B.........New York City
Miller, C. W..........Phoenix, Ariz.
Miller, M............New York City
Miller, M. S.........Cranford, N. J.
Miles, G. F..........New York City
Miner, J. H......Dobbs Ferry, N. Y.
Mitchell, E. I.......Brooklyn, N. Y.
Mitchell, S. P......Philadelphia, Pa.
Modjeski, R............Chicago, Ill.
Moffett, J. W.....New Haven, Conn.
Mogensen, O. E......New York City
Moisseiff, L. S.......Brooklyn, N. Y.
Molitor, F. A........New York City
Moore, E. J..........Yonkers, N. Y.
Moore, F. C.........New York City
Moore, F. F.........New York City
Morris, L. V.........Jamaica, N. Y.
Morrison, G..........Yonkers, N. Y.
Morse, C. F.....Southampton, N. Y.
Moss, R. E.........Glenridge, N. J.
Mott, W. E..........Pittsburgh, Pa.
Mowlds, E.............Pencoyd, Pa.
Mozart, W. J.....New Haven, Conn.
Muirhead, J. H. H...New York City
Murphy, J. F........New York City
Myers, J. H.........New York City

Nelson, J. W.......Brooklyn, N. Y.
Neumeyer, R. E......Bethlehem, Pa.
Newhall, L. R.......Oakville, Conn.
Nial, W. A.............Troy, N. Y.
Nichol, H. S.........New York City
Nichols, C. H....New Haven, Conn.
Norcross, P. H.........Atlanta, Ga.
Norris, W. H.........Portland, Me.
Northrop, A. A........Boston, Mass.

Oakley, G. I......Little Falls, N. Y.
Ockert, F. W........New York City
O'Connor, J. A.......Albany, N. Y.
Odell, F. S......Port Chester, N. Y.
Ogden, C. W........New York City
Ogden, H. N...........Ithaca, N. Y.
Ogden, J. C..........New York City
Oleri, F. J....West New York, N. J.
Orlian, I...........Philadelphia, Pa.
O'Rourke, J. F.......New York City
Orr, Alexander....Gloversville, N. Y.
Orrok, G. A......Willimantic, Conn.
Oser, H. I...........New York City
Ott, S. J..........Rutherford, N. J.

Paaswell, G..........New York City
Paddock, H. C.......Caldwell, N. J.
Paine, H. A.........New York City
Palmer, E. P......Mt. Vernon, N. Y.
Palmer, S. B........Norwich, Conn.
Pardoe, W. S.......Philadelphia, Pa.
Parker, C. J.........New York City
Parker, J. L.........Columbia, S. C.
Parkhurst, R. W.....New York City
Parmley, W. C.......New York City
Parsons, H. de B.....New York City
Parsons, R. S........New York City
Patterson, C. A...Torrington, Conn.
Payrow, H. G........Bethlehem, Pa.
Peabody, W. W....Providence, R. I.
Peck, J. S...........New York City
Peck, L. F.........Hartford, Conn.
Pegram, G. H........New York City
Peiser, F.............Newark, N. J.
Pendergrass, R. A..Philadelphia, Pa.
Perrine, G...........New York City
Perry, F. W........Brooklyn, N. Y.
Perry, J. P. H.......New York City
Perry, L................Easton, Pa.
Philips, G. W...........Wayne, Pa.
Philips, J. H..........Newark, N. J.
Pickersgill, W. C......Boston, Mass.
Pitcairn, H. H.....Philadelphia, Pa.
Pohl, C. A...........New York City
Poland, W. B........New York City
Pollock, C. D........New York City
Pond, F. H.........Brooklyn, N. Y.
Poole, C. A.........Rochester, N. Y.
Poore, H. C....East Braintree, Mass.

Porter, D. . . . . Malden, Mass.
Porter, J. E. . . . . Yonkers, N. Y.
Porter, H. T. . . . . Greenville, Pa.
Porter, J. M. . . . . Easton, Pa.
Post, C. W. . . . . Albany, N. Y.
Potter, A. . . . . New York City
Potts, C. . . . . New York City
Powell, C. U. . . . . Flushing, N. Y.
Powers, C. V. V. . . . . . New York City
Praeger, E. . . . . Brooklyn, N. Y.
Pratt, A. H. . . . . Newark, N. J.
Preston, G. H. . . . . . Bloomfield, N. J.
Preston, H. L. . . . . . New York City
Price, F. . . . . Glen Cove, N. Y.
Price, F. O. . . . . Brooklyn, N. Y.
Price, P. L. . . . . Mount Vernon, N. Y.
Priest, B. B. . . . . New York City
Prince, A. D. . . . . New York City
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Pugh, M. R. . . . . Wayne, Pa.
Putnam, G. R. . . . . Washington, D. C.

Quimby, H. H. . . . . . Philadelphia, Pa.
Quimby, J. H. . . . . Pearl River, N. Y.

Ralston, J. C. . . . . Spokane, Wash.
Rapalje, DeW. . . . . . . New York City
Rea, Samuel. . . . . . . Philadelphia, Pa.
Reeves, A. H. . . . . Clinton, N. J.
Reeves, W. F. . . . . New York City
Reichmann, A. F. . . . . . . Chicago, Ill.
Reimann, R. . . . . Relay, Md.
Reinhardt, J. B. . . . . Rochester, N. Y.
Renner, C. J. . West Saugerties, N. Y.
Reynolds, A. M. . . . . . Newark, N. J.
Reynolds, R. W. . . . . . New York City
Rhett, A. H. . . . . New York City
Richardson, J. D. . . . . Corona, N. Y.
Ricketts, A. T. . . . . . . New York City
Ridgway, H. . . . . New York City
Ridgway, R. . . . . New York City
Rights, L. D. . . . . New York City
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Ripley, J. . . . . Albany, N. Y.
Roach, J. H. . . . . New York City
Robbe, L. E. . . . . Gilboa, N. Y.
Robbins, D. W. . . . . Utica, N. Y.
Robbins, F. H. . . . . . New York City
Roberts, R. F. . . . . New York City
Roberts, T. C. . . . . . . New York City
Robinson, E. F. . . . . . . New York City
Robinson, E. W. . . . . New York City
Rodgers, G. B. . . . . New York City
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Rogers, E. H. . . . West Newton, Mass.
Ross, K. W. . . . . New York City
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Rowland, W. . . . . New York City
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Ryder, E. M. T. . . . . . New York City

Sabin, A. H. . . . . Flushing, N. Y.
Sackett, A. J. . . . . . . Flushing, N. Y.
Sackett, R. L. . . . . . State College, Pa.
Sacks, S. I. . . . . Philadelphia, Pa.
Sanborn, F. B. . . . . Boston, Mass.
Sanborn, J. F. . . . . . . New York City
Sando, W. J. . . . . . . Milwaukee, Wis.
Sanford, H. C., Long Island City, N. Y.
Sargent, P. D. . . . . Augusta, Me.
Saunders, R. S. . . . . . New York City
Saunders, W. L. . . . . New York City
Saville, C. M. . . . . . . Hartford, Conn.
Sawin, S. W. . . . . . . Marshallton, Del.
Sawyer, D. H. . . . . New York City
Sawyer, E. W. . . . . London, England
Sawyer, G. I. . . . . New York City
Scacciaferro, S. J. . . . . Clifton, N. J.
Schaefer, C. H. . . . . Philadelphia, Pa.
Schall, F. E. . . . . Bethlehem, Pa.
Scheidenhelm, F. W. . New York City
Schermerhorn, R., Jr. New York City
Schmitt, F. E. . . . . New York City
Scholtz, H. F. . . . . Passaic, N. J.
Schonberg, J. R. . . . . Elizabeth, N. J.
Schwarze, C. T. . . . . . New York City
Schweizer, R., Jr., Ridgefield Park, N. J.
Scott, W. V. . . . . Flushing, N. Y.
Scrimshaw, J. F. . . . Arlington, N. J.
Sealey, D. A. . . . . New York City
Seaman, H. B. . . . . . . New York City
Searle, C. D. . . . . New York City

Searle, L. F..........Allaben, N. Y.
Sears, H. H........New York City
Selby, O. E........Cincinnati, Ohio
Selmer, W. L.......New York City
Senior, F. S......Montgomery, N. Y.
Seward, H. C........Brooklyn, N. Y.
Shaw, D. J.........Brooklyn, N. Y.
Shaw, G. H........Philadelphia, Pa.
Shea, W. J..........Brooklyn, N. Y.
Shellenberger, L. R...Bayonne, N. J.
Shelley, H. T.......Pittsburgh, Pa.
Shepard, R. B., Jr..Wilmington, N. C.
Sherman, A. L.......Newark, N. J.
Sherman, H. J........Camden, N. J.
Shoemaker, L. H.....New York City
Sikes, Z. H.........Yonkers, N. Y.
Silliman, C.......Washington, D. C.
Sitt, W. T..........New York City
Skillin, E. S........New York City
Skinner, F. F.....Mt. Vernon, N. Y.
Skinner, F. W.......New York City
Skinner, J. F.......Rochester, N. Y.
Skinner, T. H.........Oneida, N. Y.
Sloan, S. A.......Philadelphia, Pa.
Slocum, H. S........New York City
Smith, A...........Elizabeth, N. J.
Smith, C. W.....Newburyport, Mass.
Smith, E. M........New York City
Smith, H. E.....Binghamton, N. Y.
Smith, H. H........New York City
Smith, J. R..........New York City
Smith, J. W........New York City
Smith, M. A........Brooklyn, N. Y.
Smith, M. H........New York City
Smith, W. F..........Harriman, Pa.
Smoley, C. K..........Scranton, Pa.
Snell, E. B..........New York City
Snell, H. B..........Deposit, N. Y.
Snell, T. C. B.......New York City
Snow, C. H........New York City
Snow J. B........Forest Hills, N. Y.
Snyder, F. A........New York City
Soest, H. C..........New York City
Solomon, G. R......New York City
Soper, G. A..........New York City
Spear, C. J.........New York City
Spear, W. E........Merrick, N. Y.
Spencer, T. N........New York City
Sperry, H. M........New York City
Spofford, C. M.....Cambridge, Mass.
Squire, E. J........Brooklyn, N. Y.
Stark, C. W......Tarrytown, N. Y.
Stearns, F. L........Scarsdale, N. Y.
Stearns, R. H........New York City
Stepath, C. U.....Springfield, Mass.
Steele, H. W........Uniontown, Pa.
Steffens, W. F.......New York City
Stern, E. W........New York City
Stephens, A. W......New York City
Stevens, J. F.....Manchuria, China
Stevenson, W. F..New Rochelle, N. Y.
Stiles, A. I..........New York City
Stone, W. W.......Glen Cove, N. Y.
Stowe, H. C.........Brooklyn, N. Y.
Stowitts, G. P......Yonkers, N. Y.
Strachan, J........Brooklyn, N. Y.
Strachan, J. J.....New York City
Strachan, R. C.....New York City
Strehan, G. E........New York City
Strickler, G. B....Washington, D. C.
Strobel, C. L............Chicago, Ill.
Stuart, F. L........New York City
Sudler, C. E.........New York City
Sullivan, J. F.......New York City
Swaab, S. M.......Philadelphia, Pa.
Swasey, A...........Cleveland, Ohio
Swezey, E. C..Clinton Corners, N. Y.
Swift, W. E.....New Canaan, Conn.
Swindells, J. S.......New York City
Symonds, G. R. B.....Nutley, N. J.

Taber, G. A...........Boston, Mass.
Taggart, R. C........Albany, N. Y.
Tainter, F. S........New York City
Talbot, A. N............Urbana, Ill.
Talbot, E.........Weehawken, N. J.
Taylor, C. F........Foochow, China
Taylor, E. A.........New York City
Taylor, G. L.........Pittsburgh, Pa.
Taylor, M. P..........Hopewell, Va.
Taylor, W. G........Newark, N. J.
Teal, J. E............Baltimore, Md.
Temple, E. B......Philadelphia, Pa.
Tenny, W. R........Brooklyn, N. Y.

Theban, J. G. . . . Pleasantville, N. Y.
Thomas, C. D. . . . . . Hempstead, N. Y.
Thomassen, V. G. . . . Brooklyn, N. Y.
Thomes, E. H. . . . . . Jamaica, N. Y.
Thompson, C. R. . . . Philadelphia, Pa.
Thompson, P. . . . . Yonkers, N. Y.
Thompson, S. E. . . . . . . Boston, Mass.
Thompson, W. G. B. . . Trenton, N. J.
Thomson, T. K. . . . . . New York City
Tidd, A. W. . . . . . White Plains, N. Y.
Tighe, J. L. . . . . Holyoke, Mass.
Timberlake, S. M. . . . Brooklyn, N. Y.
Tippet, H. J. . . . . . New Haven, Conn.
Tompkins, C. H. . Washington, D. C.
Tompkins, E. de V. . . New York City.
Torrey, J. E. . . . . Paterson, N. J.
Tower, J. W. . . . . New York City
Townsend, C. McD. . . Brooklyn, N. Y.
Townsend, F. T. . . . . . New York City
Trautwine, J. C., Jr. Philadelphia, Pa.
Travell, W. B. . . . . . . New York City
Trees, M. J. . . . . Chicago, Ill.
Tretter, G. A. . . . . Roanoke, Va.
Tribus, L. L. . . . . New York City
Triest, W. G. . . . . New York City
Troelsch, H. W. . . . . New York City
Trout, C. E.,
West New Brighton, N. Y.
Trueheart, E. . . . . La Paz, Bolivia
Trumbull, M. K. . . . . . New York City
Tucker, L. W. . . . . Rutherford, N. J.
Tull, R. W. . . . . New York City
Turner, D. L. . . . . New York City
Turner, H. C. . . . . New York City
Tuska, G. R. . . . . New York City
Tuttle, A. S. . . . . New York City

Ungrich, M. J. . . . . . . New York City
Upton, J. . . . . Flushing, N. Y.

Vail, E. M. . . . . Plainfield, N. J.
Van Cleve, H. P. . . . . Cranford, N. J.
Vanderbrook, R. H. . Brooklyn, N. Y.
Van Duyne, J. R. . . . . Newark, N. J.
Van Dyke, C. W. . . . . New York City
Van Keuren, C. A. . Jersey City, N. J.
Van Scoyoc, H. S.,
Montreal, Que., Canada
Van Suetendael, A. O. Yonkers, N. Y.
Verner, J. . . . . Linden, N. J.
Vermeule, C. C. . . . . . New York City
Verveer, E. L. . . . . . . New York City
Vincent, J. I. . . . . New York City
Vogel, J. L. . . . . Newark, N. J.
Voorhees, B. S. . . . . . . Yonkers, N. Y.
Vredenburgh, W. . . . New York City.
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Wagner, S. T. . . . . . Philadelphia, Pa.
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Waldron, S. P. . . . . Boston, Mass.
Walker, W. T. . . . Minneapolis, Minn.
Wall, E. E. . . . . St. Louis, Mo.
Warnock, W. H. . . Greenwich, Conn.
Warwick, C. L. . . . . Philadelphia, Pa.
Watson, C. D. . . . . Madison, N. J.
Watson, G. L. . . . . New York City
Webb, W. T. . Rio de Janiero, Brazil
Webster, A. L. . . . . . New York City
Webster, G. S. . . . . . Philadelphia, Pa.
Webster, M. A. . . . . . Philadelphia, Pa.
Weed, L. W. . . . . Brooklyn, N. Y.
Weller, W. E. . . . . Binghamton, N. Y.
Wells, C. E. . . . . North Adams, Mass.
Welty, H. T. . . . . New York City
Wendt, E. F. . . . . . Washington, D. C.
Weston, C. M. . . . . New York City
Weston, R. S. . . . . Boston, Mass.
Wheeler, F. L., Jr. . . . . Newark, N. J.
Wheeler, H. R. . . . . . . New York City
Wheelock, D. F. A. . . . . . Warren, Pa.
Whipple, G. C. . . . . Cambridge, Mass.
Whipple, J. B. . . . . Bridgeport, Conn.
Whinery, S. . . . . New York City
Whiskeman, J. P. . . . . New York City
White, L. . . . . New York City
White, W. M. . . . . New York City
Whited, W. . . . . Harrisburg, Pa.
Whitney, G. C. . . . . . Brooklyn, N. Y.

Whitson, A. U......Flushing, N. Y.
Widdicombe, S. H...Phœnixville, Pa.
Wigley, C. G........New York City
Wilcock, F.........Brooklyn, N. Y.
Wildes, W. G......Rochester, N. Y.
Wilgus, W. J........New York City
Wilkerson, T. J...Beaver Falls, Pa.
Willcox, H..........New York City
Williams, F......East Orange, N. J.
Williams, G. S.....Ann Arbor, Mich.
Williams, J. P. J...New York City
Williams, M. W.....New York City
Willoughby, J. E..Wilmington, N. C.
Wilmot, J...........New York City
Wilson, B...........New York City
Wilson, C. W. S. New Rochelle, N. Y.
Wilson, W. T......New York City
Wilson, W...........New York City
Winblad, B. E.........New York City
Winn, G. P..........Nashua, N. H.
Winslow, F. I....Framingham, Mass.
Winsor, F. E.....Providence, R. I.
Winsor, G. A.....Pleasantville, N. Y.
Winsor, H. D.,
West New Brighton, N. Y.
Wintermute, F. C..Wilkes-Barre, Pa.
Wise, J. G.....White Plains, N. Y.
Wise, R. S...........Passaic, N. J.
Wolfe, F. C..........Baltimore, Md.
Wolff, R. B........Glendale, N. Y.
Wood, W. B........Wilmington, Del.
Woodard, S. H.....New York City
Wortendyke, N. D..Jersey City, N. J.
Wright, F. H........Pittsburgh, Pa.
Wright, F. J........Paterson, N. J.
Wyckoff, C. R.........New York City

Yates, J. J........Jersey City, N. J.
Yereance, W. B......New York City
Young, C. G.........New York City
Young, H. A.......Maplewood, N. J.

Zeltner, E. L........Elmhurst, N. Y.
Zook, M. A.........Plainfield, N. J.

WORLD ACTIVITIES AND THEIR EFFECT UPON THE ENGINEER

Address by Frank A. Vanderlip, Esq., at the Annual Meeting, January 19th, 1922.

Coming down the elevator in the Equitable Building recently, I had an optimist for a co-passenger, that is, I would say he was an optimist. One man said to his companion, "What do you think of business"? The other replied, "If they get that European situation fixed up, I think we are going to have good business." So do I. I am not certain, however, that any one who believes the European situation is going to be fixed up, comprehends what the European situation is. I am afraid the European situation is not going to be fixed up right away. It has been fixed up somewhat. Any one who was in Europe at the end of the war and who, to-day, would make a comparison with the situation he saw then, would say that a great deal had been fixed up. There has been real material recovery pretty much all over Europe. The wound of the war itself is being healed. The wound of the war itself was not such an impossible wound to heal. It was a horrible wound. Europe was terribly hurt by the direct damage of the war and by its cost; but the world has had wars before—never one quite like this—and has recovered more or less quickly, and could have recovered from this direct hurt, I believe, without any such cataclysm as we have had.

Although the wound of the war was a terrible one; the wound of the peace, I believe, was worse. That is a very strong statement, which perhaps I should not make without some explanation; but to my mind the thing that Europe is suffering from to-day, in the main, has resulted from an unwise peace, conceived in such a way that there was no healing qualities in it, conceived with a desire to crush; and it is easy to see why there was a desire to crush. Any one who traveled over that battle-front, as I did, directly after the war, who saw the terrible damage done, can understand how men meeting with that fresh in their minds should have created a peace that was not magnanimous. It was not a magnanimous peace, nor was it a wise peace, economically speaking. It has fanned the old racial prejudices into a heat, and it has built new fires of intense nationalism. It was of such a character that the faith of nations in one another, in their good will, in their fairness, in their unselfishness, has been badly damaged.

The question is sometimes put, Is European civilization in danger? Is there going to be a decay of European civilization? When people cannot live together, civilization has already begun to decay. Civilization is not measured really by bathtubs and Pullman cars; it is measured by the ability of people to live together. That is the definition of civilization, to my mind. And European peoples are showing an inability to live together. There is intense nationalism—selfishness; there is a desire of each people for its own welfare without much, if any, regard to the welfare of others. That is a narrow-minded desire. It is a desire, really, that cannot be fulfilled, for Europe is an economic unity. I believe that unless Europe is brought to see that, and in

seeing it, governs itself in the light of that fact, there will be still further deterioration of European civilization.

There are nearly half a billion of people in Europe, or in Europe and just that edge of Asia that is really also immediately affected by the war—between one-third and one-quarter of all the people in the world.

The greatest fact to my mind, in all the history of humanity, is the fact of the growth of population in the last century. People talked about the recovery after the Napoleonic wars, and drew comparisons as to what might be expected after this war; and they did that, without any real comprehension of how intricate European society had become; what that unity I speak of meant to Europe, and, conversely, what the breaking up of that unity entailed.

At the end of the Napoleonic wars there were only 175 000 000 people in Europe, and there are now in Europe itself 440 000 000. That change signifies something important in the method by which those people lived. One hundred years ago, Europe was self-sustaining; most countries were individually self-sustaining. There was not a great amount of foreign trade; and there was, as a result of the Napoleonic wars, no serious break-up of world commerce. With the advent of the industrial age, of the age which your forerunners, the engineers of the last century, created, there came this tremendous increase of population made possible by the work of engineers, by better transportation, by the development of power and machinery. So there grew up in those European countries great populations getting an increasingly better living by working in the shops, turning out manufactured goods, transporting them over long distances, and exchanging them for food. With easier conditions of life came a rapid increase of population, until, at the outbreak of the World War, there were 100 000 000 people in Europe who were supporting themselves in workshops and drawing their food from foreign countries, supporting themselves by manufacturing for exports and exchanging their goods for the food and raw material of foreign countries.

Now, the thing that has happened since the war, the thing that makes the European situation so gloomy in some of its aspects, is the breaking down of the whole commercial machine which permitted this interchange of goods, permitted these great populations to live by the exchange of their manufactured goods for the food of other countries. England is a notable example of that. England needs to feed about 30 000 000 of her people with imported food. England must have a composed, orderly world, a world in which foreign trade can be carried on, so that the product of her workshops can go out and create the exchange and bring in the food that she must have.

Germany, to an extent, is in something of the same situation. Approximately, 10 000 000 of her 60 000 000 people were fed by imported food. Several of the smaller countries are in the same situation, that is, Belgium, Switzerland, and the present Czecho-Slovakia. We think of Czecho-Slovakia as an Eastern agricultural country. In fact, it is a great industrial country. Three-fourths of the industries of the old Austrian Empire went to Czecho-Slovakia, and fully half her people are industrially employed, and therefore she feels this food problem, this necessity to exchange goods in order that food may be brought in.

It is the breakdown of the machinery of international trade that I conceive is the great wound from which Europe is suffering to-day. Why has it broken down? The wants are there; the capacity is there. Any one who will travel over all Europe, as I did this summer and fall, and who will travel with open eyes, looking at Europe from the economic point of view, cannot but be struck with the potential richness of Europe, the wonderful extent of her agricultural possibilities, her great plants, her fine transportation, canals, rivers, and railroads. Everything is there in a material way for the welfare of Europe; but a hand of paralysis seems to have been laid on many of those countries, and on many of the people. There is no longer an interchange of goods going on as in pre-war times.

Let us analyze the reason for that. One of the features of the Paris Treaty was self-determination, self-determination that broke up many of the old countries and created many additional new ones. The old Austrian-Hungarian Empire is particularly an example. There were well over 50 000 000 people in the heart of Europe living in an economic unity; there was free interchange of goods; they were a single economic unit. Old Austria was so split up that there was left not much more than a strip of Alpine country, with 6 500 000 people, including a city of nearly 2 000 000. Two-thirds of the whole country was industrial; with about 2 000 000 agriculturists who were placed on land of a character that produced no more than the people needed who lived on that land.

Here was this country having to import all but 100 days' food supply, and having no way to get it but by the export of goods, surrounded by new nations carved largely from the old Empire, that were antagonistic, that were economically blind, that interposed every sort of obstacle in the way of trade. For months, no freight train could be moved across any border. The railroads of the Austrian Empire were the property of the old Government. When those new countries were formed, there was no defining of railroad property. If a freight train crossed a border, the cars never came back again, so they did not cross, and the borders became Chinese walls.

There was for a long time the same situation on the rivers and canals. There was no apportionment, at the time the treaty was made, of the water traffic, and it could not move. That was one of the difficulties. Another was the deterioration of the matter of currency which was common to nearly all Europe, and certainly to all Central Europe. All those Governments after the war, found themselves with budget expenses running beyond their tax receipts. They increased taxes, but there was a ghastly deficit in all those budgets.

A nation with a gap in its budget has the choice of just two ways of filling it: It can borrow money, and to do that it must have political courage and credit. There is another, an easier way—easier it appears at the start—a nation can print money, and that was the course which all the Central European nations followed. They filled the gap in their budget by printing money. The result was a deterioration in the value of the money—a perfectly inevitable result. Nearly all those Governments ran railroads; some of them ran other enterprises. The cost of running railroads increased as the currency deteriorated. The Governments found it impossible to increase the freight

rates as rapidly as the cost of operation increased; I say they found it impossible. they at least did not do it. It was impossible for officials to do it and continue in office; so they began to pile up huge deficits in operating their railroads. In 1920, Germany showed a deficit of 17 000 000 000 marks in operating her railroads and in 1921 considerably more.

Those nations that were short of food had to resort to another thing that led to increasing their budget deficits. The Goverments took command of the food importation. They bought wheat in the markets of the world at a gold equivalent, but when they brought that wheat into the country, wages had not changed—they never will change as rapidly as currency changes in its value—and the Governments felt that they had to sell this food at a price within the range of the ordinary people. So, they bought grain for gold at one price and sold it for a fraction of that price in paper to their own people, and there again huge deficits were created; and as those deficits grew, more printing was necessary. They just traveled down the spiral staircase—more printing, more deficit—more deficit more printing—until we see practically in all the Central European nations a deterioration of currency that is the most shocking in the whole experience of the financial world—a deterioration that keeps going on, a deterioration that has in 1921 brought some currencies down to one-tenth of what their value was at the beginning of the year, and many others to one-half or one-third.

The effect of a depreciating currency, a currency depreciated by such enormous inflation as these countries have gone through, is most profound on the whole social life. The whole standard of value has become something in which no dependence can be placed. One can tell nothing about what the future holds, and that has made the greatest difficulty in trade. A man who can make no future calculation, measured in the money of his country, is at a fatal disadvantage in carrying on a business, and that is the situation in which the business men of most of these countries are placed.

A deteriorating currency, however, has some temporary and apparently good effects. You hear me speaking in a pessimistic way about the European situation, and I do not doubt that there are men here who have certain reservations. They say, "Oh, I do not know about that; I have heard other people who have come home from Europe; they have seen Europe, too, and they have seen a great improvement over there. They have seen people busy; they have been in Germany; they have seen tremendous activity there."

That is true. I have been in Germany and have seen that tremendous industrial activity. I have seen that country change from the work of war to the work of peace in a most phenomenal way. I have seen those great Krupp Works at Essen, which turned out such an enormous quantity of ammunition and arms, turn completely to the works of peace, and employ thousands more men than they were employing at the outbreak of the war. I have seen all Germany busy, and I have seen her foreign trade apparently developing with great rapidity. I have seen her showing a command in the foreign markets that has frightened the manufacturers of competing nations. I have seen her supplying goods at rates astonishingly below what we are able to supply them. Why is this? It is because a deteriorating currency stimulates

exports and may bring great profits to exporters during the period in which the currency deteriorates. An exporter sells his goods in the world markets for the equivalent of gold. He produces them in the home market with the payment of paper. The gold is worth a constantly increasing amount of paper. Wages are never adjusted as rapidly as the currency depreciates. So, he finds himself while the depreciation goes on, at a very great advantage over his foreign competitors. That advantage is of a temporary character; it holds only while the depreciation continues. It stops when the depreciation stops, and a reverse occurs if there is any attempt to bring the currency back to its normal. The manufacturer will then find himself under as great a disadvantage as he was at an advantage during the period of deterioration.

I think Germany has now reached the point where those advantages will soon cease. Wages are not yet adjusted to any comparison with world wages. The wage scale in Germany to-day is an absurdity, measured in gold, and compared with our own wage scale, and is for the time being resulting in an ability to compete with all other manufacturing nations. Deterioration of currency, however, cannot go much further.

I was told a story to-day of a man who had purchased a jack-knife in Berlin for thirty-five cents. He thought it was a pretty good knife at that price, and he went into one of the great department stores in Chicago to make a comparison. He found there the same kind of knife listed at $5.50. That is a rather extravagant case, but there are many cases of what seems to be an almost inexplicable difference in price. I think Germany's ability to do that sort of thing is ceasing. Wages must be adjusted, are being adjusted all the time; the mark has almost fallen to as low a point as it can without vanishing. It can still go, and I think is not unlikely to go, the course of the Austrian crown and the Polish mark; but even that will not take it much further.

Of these falling currencies, Austria and Poland offer the most notable examples; Germany the most significant one because of the size of the country. Hungary, Roumania, and all the Central European nations, have experienced inflation, these deteriorating currencies, this complete upsetting of the whole economic life, these and many other causes, have paralyzed the ability of those countries to trade. They are not producing, at least they are not trading, in anything like the old volume. You have all heard the story of this superficially better situation, but I think you must go beneath that. I think you must analyze the economic and the financial situation. The financial situation governs.

It is possible to have, for a time at least, a certain amount of individual prosperity when the Government's finances are in a bad way. Government finances throughout Europe are in a very bad way and in a progressively deteriorating situation. That is not universally true, but it is true that in many of the countries the financial situation is progressively deteriorating. The increase of debt since the Armistice is one of the amazing facts of European finance.

France has added to her debt since the Armistice nearly half as much as she added during the war. Italy has added 25 000 000 000 or 30 000 000 000

lire to her debt since the Armistice. The increase of debt in Germany has been colossal, whereas the increase in Austria and in Poland has not been so great, except in the increase in currency; but that is true only because those Governments had not the credit to create a debt. They have created currency in an endlessly flowing stream. Poland in 1921 had Government expenses of about 111 000 000 000 Polish marks, while her income from taxation was 10 000 000 000. It is no wonder that a nation with such a gap in its budget, finding no way to close that gap but to print more paper, proceeds into what is very close to National bankruptcy.

If that is the financial picture of Europe, and it is, what is to be the outcome? Some of you will say that you doubt if this is really the picture. Some of you might answer "Oh, I read to-night that France had made a further large reduction of her debt to the Bank of France, and I read a few days ago that France was balancing her budget." Well, if you did, both those things are qualifiedly true. France balances a budget that she calls her ordinary budget, and then she has another budget quite as large that she calls an extraordinary budget, and she hopes for reimbursement for the expenditures under that from the German indemnity; but, in the meantime, she increases her debt; she has increased it until she has now 65 000 000 000 francs of floating debt, unfunded debt, short-term treasury notes. She is committed to spend 60 000 000 000 more on reparations within the next three years. She has hoped to get that back from Germany's indemnity; and it is easy to see why she is so strenuous on the point of insisting that Germany pay according to the terms of the London Conference. Germany, however, cannot pay according to those terms. They are impossible of execution, and so France piles up a debt. She says she has balanced her budget; but if you compare her debt figures, they are steadily and rapidly growing.

The same thing is true of Italy, but she is coming nearer balancing her budget, however. Italy, of all the countries in Europe, is showing the greatest courage about taxation. She is levying taxes and collecting them. All the European nations are levying heavy taxes, but most of them are not collecting them. Italy taxes with great severity. Italy had a deficit two years ago of 14 000 000 000 lire which she is going to reduce this fiscal year to 4 000 000 000. On the other hand, however, Italy is an example of one of those countries that must import. She must import food. She must import every pound of coal. And she has very little of anything to export. She used to balance her foreign trade by tourists spending 1 000 000 000 lire, gold, by her emigrants remitting 1 000 000 000 lire a year; but, to-day, those sources of income have been very much cut down, and she finds her expenditures high and particularly her necessity for imports must be translated into gold, with a result that she is importing about two and one-half times as much as she exports and is really in a ghastly situation so far as her foreign trade is concerned. She seems to me to have done about everything she could in the way of handling her internal fiscal affairs, handling well, too, her internal social affairs.

Here is one of the interesting situations. About a year ago we heard about Italy being Bolshevist, and there was pretty good evidence of it. There were strikes; men took possession of factories, turned out the owners, and declared

that the workmen would run the factories. With the greatest good sense the Government and the owners said, "All right, try it"; and in about a fortnight the men decided that they could not run the factories, and gracefully and fully retired, and turned them back to their owners. If my observation is correct, there is a better relation to-day between labor and capital in Italy then in any other European country. I know that is rather a remarkable statement, and I know that in the face of a situation where they must steadily reduce wages, as they must, that is a statement that may not hold good for a great while, but in the summer and fall of 1921, there were certainly evidences of such a situation.

Speaking of labor conditions, the most interesting labor situation is, of course, in England, where there is still this enormous unemployment—1 600 000 men receiving weekly doles, and some 2 000 000 more on short time; and remember this is out of an industrial population of only 7 000 000 or 8 000 000. I was saying that England is the most illustrious example of a country that has become so industrialized that it must import a vast quantity of food for its people, that England must import food for 30 000 000. You know that tells the story of the strain in the Entente, the strain between England and France.

England cannot live without a restored Europe. England has industrial difficulties at home; but if all those were corrected, she would still be facing the greatest crisis she has ever faced, because of her lack of markets, because of this breakdown in the exchange of goods internationally. England must do everything within her power to rehabilitate the commerce of Europe. She wants to see Germany rehabilitated. Germany was her best customer, and Germany has practically ceased to be a customer. She wants to see—and it is her very life blood—the whole of Europe rehabilitated, and something like the old-time order restored, so that she can again send out into the world her products and get the food that she must have to support her people.

I think the English situation presents one of the most serious in Europe. They will manage it with consummate ability. They will show the greatest common sense all through the whole situation and will grapple it with energy and experience. They will handle it better than any other people on earth could handle it; but, nevertheless, they are facing a crisis that demands the restoration of the economic order of Europe, that demands a restoration of markets. It is a situation that cannot be corrected within England. It must be corrected outside by economic rehabilitation. That is why you find Lloyd-George proposing a General Conference; that is why you find the whole body of English statesmanship centered on reconstruction.

France, on the other hand, is self-supporting, practically self-supporting. Her imports and exports balance. She can feed herself. She is desperately afraid of her bigger neighbor, Germany. She does not know quite what she wants, of two things, as to Germany. For a time she thought she might possibly have both a crushed Germany and an indemnity. She cannot have both. She cannot have, in any event, all the indemnity that she hoped for. The amount of indemnity that was proposed was impossible of payment. I think any judge, any authority outside of France to-day, would agree with that statement. That is pretty much the universal opinion outside of France, that

the full terms of the indemnity as laid, were impossible. France, however, with good reason, fears the economic rehabilitation of Germany, and does not feel either the falsely stimulated exports of Germany as England does now, or the loss of markets that England feels.

So there are two lines of interest that are not parallel, England feeling that her very life depends on the general economic habilitation of Europe, the restoration of the Old World order of trade; France feeling that, first of all, she must have protection and that she must have payment for rehabilitation; and that if she crushes Germany in getting the reparations, she will have done a good job, if she does not crush her too soon to get reparations.

Now, what about it all? How is it coming out? What is to be done? Something of great importance might be done at this Economic Conference at Genoa. Personally, I doubt if there will be, if the main Powers concerned cannot go into that Conference with any program on which they can agree, and there does not seem to be the slightest possibility that they can. The probability of a fortunate outcome of such a Conference is not good; and still I believe the Conference will be of great importance. It will impress all Europe, providing France and Russia both attend. Russia seems quite certain that she will attend; France in some doubt unless the agenda of the Conference is made so as to exclude a great many subjects that really ought to be discussed there. So far as the United States is concerned, we are still hesitating.

I believe that Conference ought to be held and that we should be represented. You may say that this is Europe's affair. She has got into a terrible situation through her own fault. If she is not civilized, if her peoples can not live together, if their selfishness and their blindness and racial antagonisms and their National hatreds are such that they have destroyed the old machinery of an intricate civilization, why they must be cured in spirit, and you may ask what can we do about that? There is some ground for taking that view, because it is back to a regeneration of spirit that you have to go for the fundamental cure of Europe. Do not let anybody make you believe that there is some panacea, some scheme, some formula that could be invented that would cure the European situation. You have to go clear back into the human spirit to cure Europe really and get these people to live more considerately together.

It strikes me that there is a sort of international anarchy in Europe. You have this great number of small nations, this great number of races, these intense antagonisms; each nation believing in its supreme sovereignty, its right to do what it will without regard to its fellows; all these nations governed by no law in regard to their association one with another; and it is quite largely that sort of international anarchy, that National self-consciousness that is making recovery so difficult there.

What could we do at an international, economic conference? What should be our rôle if we were to go there? How could we be helpful? The answers are not easy. In the first place, I suppose it would not be possible to send any group of men who could be said to represent this country, who could commit us to any line of action. It would be impossible to constitute any such group. Therefore, we would be at a disadvantage in a conference at

which other Governments sent representatives who could commit their Governments. We are afraid that we might have to discuss the inter-allied debt, and that would not be a good atmosphere or a good occasion in which to discuss it. I think that is true. It would not be the right place for us to discuss the inter-allied debt. That, however, is something that we ought to discuss, and something we ought to discuss with great promptness, for it is one of the heavy things that is overhanging the European economic situation.

There is one line in which we could come into an international economic conference, and bring to it a great deal of help. I believe that those countries that have deteriorated their currency to the point that the Central European countries have, have to agree on a new form of currency that will not be a Government obligation, or will not be issued by a bank of issue controlled by a Government so that its issues are practically the issues of a Government printing press. Such countries at Poland and Austria and Hungary, and Germany, too, I think, are likely to come to some banking scheme for an issue of currency where the bank will be divorced from the Government and the bank issues divorced from the Government printing press.

I believe it would be possible to organize a bank which would cover many countries of Europe, giving them a reformed currency issued by a bank that was built very much on the lines of our own Federal Reserve banking system. If we were present at such a conference I think we could very sensibly direct the discussion to the rehabilitation of currencies and perhaps the organization of a great world bank in which we might take part.

I am not sure, however, that what we need for such a conference is our wisest bankers or our greatest economists or even our best politicians. Europe needs moral leadership more than she needs material help. I do not believe we can do so very much in the way of material help. We ought to be able to do a great deal in the way of moral leadership.

We have had the experience that no other people ever had of a vast country under one economic organization. I think we could show Europe, we could point to the significance of an economic unity in Europe, to the need of conducting their affairs with less selfishness, to the need of recognizing that the welfare of each country lies in the welfare of all of them. You cannot fix up Europe by fixing up a spot here and there; you have to make a very comprehensive job of it; and it is a job that is really going to take moral leadership to put it in its right light. We ought to be great enough to do that, to be helpful at least in doing that—not to do it, I do not mean that, but to make a helpful contribution. I would like to see the United States take part in the Genoa Conference, and take part with the greatest moral forces that we have. Then, I would like to see here a country that would stand behind the men that are sent. That is where the individual opportunity comes.

One hears these generalities, these incomprehensible figures, hears about these vast economical and political forces, and is apt to fold his hands and say "What can I do in such a situation?" I think, however, we have our individual part to play, in understanding it, in coming to that understanding with a sufficiently fine spirit, so that we begin to form a fine body of public opinion which will be unselfish. If we want to guide toward international

unselfishness the continent of Europe, we must be nationally unselfish ourselves; and we should have an understanding public opinion backed by a fine, generous spirit, if we, as a nation, are to play a great rôle in this moral leadership. We have not made very much progress at it yet; it is a tremendous task; but there is a growing interest. There is some interest that arises from an economic fear. I do not take much stock in that. I am not afraid of the economic future of America, whatever the economic future of Europe may be. I do not mean that we are not tremendously concerned with the economic future of Europe. It would be best for us to live in a well-ordered world, in which we could have a great international trade. It would unquestionably be best; but we are situated as no people ever were situated in all time before, commanding a whole continent with every type of resource, all under one Government, all in one economic unity; and I am convinced that we can have a great share of prosperity within ourselves. Isolation, it is true, would find us with certain plants over-developed. We can manufacture more steel than we can use. We can produce more copper than we can consume. We can raise more cotton than we can as yet weave. It would take some readjustment; but I cannot feel that a country with such resources, could not readjust, will not readjust, and have a great measure of prosperity. So I would not be forced into the European situation by economic fear.

I would not be blind to the economic advantage of a restoration of Europe. It is very great. We ought on that score alone to do all that we can to understand, to participate, and to be helpful; but there is a stronger reason than that. The reason is that we have laid at our feet the moral leadership of the world, and we ought to move to take it up. That means that there must be such gatherings as this, seriously thinking about the problems of Europe, seriously measuring our responsibility, seeing that it is after all in its very fundamentals a spiritual question, that there must be a regeneration of spirit there, and that we ought to meet it and lead it with a spirit of unselfishness, of fairness, of good will. Now, that is not going just to happen. It is going to come out of our inner selves, and it is out of endless audiences of this sort, out of endless numbers of readers who will ponder, understand, and translate into sound, public opinion the best that is in them, that we will make our contribution to Europe.

ITEMS OF INTEREST

This Society is not responsible for any statement made or opinion expressed in its publications.

The Committee on Publications will be glad to receive communications of general interest to the Society, and will consider them for publication in *Proceedings* in "Items of Interest". This is intended to cover letters or suggestions from our membership concerning matters which are not of a technical character. Such communications, however, must not be controversial or commercial.

THE ENGINEERING FOUNDATION

The Engineering Foundation was established in 1914 "for the furtherance of research in science and engineering, or for the advancement in any other manner of the Profession of Engineering and the good of mankind", and for the following purposes: To promote and support worthy researches related to engineering in all its branches; to establish and operate engineering research laboratories, if funds be provided therefor; to co-operate with National Research Council and the Engineering Societies in the stimulation and co-ordination of scientific research.

Endowment Funds Needed.

The Foundation needs a large increase of endowment. It is obliged frequently to refuse to support research projects brought to it because it lacks funds. Gifts of $1 000 or more are desired. Each donor of $250 000 or more will be honored as a Founder. A gift of $50 000 has been offered contingent on the receipt of nine other gifts of $50 000 each. Gifts to the Foundation are exempt from income tax. A gift for research is a productive investment.

The Foundation is compiling a directory of the hydraulic laboratories of the United States, and is planning an investigation of industrial education and training. It undertakes useful researches which do not promise profits sufficient to tempt industrial organizations to undertake them, researches which should be made under disinterested auspices, and researches which lie outside the province of Government bureaus.

The Engineering Foundation is administered under the auspices of the United Engineering Society, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, by a board of thirteen representatives of these Societies, and three members at large.

A progress report of the Foundation, a form of Deed of Gift, and other information will be sent by the Secretary, Alfred D. Flinn, M. Am. Soc. C. E., 29 West 39th Street, New York City, on request.

Abstract from the Report of the Director of the Advisory Board on Highway Research, Division of Engineering, National Research Council, January 16th, 1922

The following abstract of the report of the Director of the Advisory Board on Highway Research, includes the history of the development of the Advisory Board and its Committees; a report of the activities of the Director; a statement of the financial condition of the Advisory Board; and a survey of the field of highway research.

Chronological Statement

The National Research Council was established in the spring of 1916, when President Wilson requested the National Academy of Sciences to organize the scientific and engineering forces of the United States for the purpose of defense. The Engineering Committee of the National Research Council did effective work during the World War.

The Division of Engineering of the National Research Council occupies offices in the Engineering Societies' Building, 33 West 39th Street, New York City.

Advisory Board.—On October 8th, 1919, Professor A. N. Talbot, Past-President Am. Soc. C. E., and Dean Anson Marston, M. Am. Soc. C. E., representatives of organizations in the Division of Engineering, met in Chicago, Ill., in conjunction with the following:

For the U. S. Bureau of Public Roads:

- T. H. MacDonald, Chief;
- A. T. Goldbeck, Assoc. M. Am. Soc. C. E., in Charge of Tests and Investigations;
- T. W. Allen, M. Am. Soc. C. E., Chief, Division of Control;
- J. T. Voshell, M. Am. Soc. C. E., District Engineer.

For the Mississippi Valley State Highway Department Association:

- Clifford Older, M. Am. Soc. C. E., President.

After discussing the importance and necessity for the immediate inauguration of a National program for highway research, and listing the highway research agencies, it was recommended in a report dated October 27th, 1919, and signed by Messrs. A. N. Talbot, Anson Marston, H. H. Porter, M. Am. Soc. C. E., and George S. Webster, Past-President, Am. Soc. C. E., that a sub-committee of the Engineering Division be appointed to co-operate with the Chairman in co-ordinating the various highway research committees, and that six committees be constituted as follows:

(1) Committee on the Economic Theory of Highway Improvement:

Purpose.—Determination of all elements of cost of highway transportation (both motor vehicle and animal drawn), and the effect on each cost element of each feature of highway improvement (improved surface, grade reduction, elimination of rise and fall, etc.) to enable reliable and scientific determination of the sums which could be economically expended for scientific highway improvement.

(2) Committee on Structural Design of Roads:

Purpose.—Experimental determination of stresses, strains, and behavior, of impact and abrasion in actual roadways under actual traffic; including also the effect of temperature variations, freezing and thaw-

ing, non-uniform subgrades and other factors; in order to establish reliable scientific engineering theory for the structural design of roads.

(3) Committee on Properties of Road Materials:

Purpose.—To investigate the properties of road materials and their combinations, including devising and standardizing tests.

(4) Committee on Methods of Road Construction.

(5) Committee on Maintenance Methods and Design.

(6) Committee on Highway Bridge and Culvert Research.

On October 26th, 1920, the Chairman of the Engineering Division addressed a communication to the governing boards of certain National organizations, Federal and State departments, and educational institutions, stating the need for highway research, and the projected committee organization, and inviting representatives to a conference on November 11th, 1920, for the purpose of completing the organization.

On November 11th, 1920, an Advisory Board on Highway Research was organized and by-laws were adopted. The officers were Chairman, Vice-Chairman, and Director, and Administrative Committees, Executive, and Ways and Means, and Research Committees on Bibliography, Economic Theory of Highway Improvement, Structural Design of Roads, and Character and Use of Road Materials, were created.

The purposes of the Board are, briefly: To prepare a comprehensive National program for highway research; to assist existing organizations to co-ordinate their activities therein; and to collect and distribute information of completed and current research.

On July 11th, 1921, the Executive Committee met and engaged a Director; authorized the Chairman and Vice-Chairman to prepare co-operative agreements with the Bureau of Public Roads, State Highway Departments, and other suitable organizations for instituting and co-ordinating a National program for highway research.

Members of Advisory Board.—The following are the officers and constituent members as of the date of this report:

Officers:

Chairman, Anson Marston, M. Am. Soc. C. E., Member, Iowa Highway Commission.

Vice-Chairman, Alfred D. Flinn, M. Am. Soc. C. E., Secretary, Engineering Foundation; Chairman, Division of Engineering National Research Council.

Director, W. K. Hatt, M. Am. Soc. C. E.

Other Members of Executive Committee:

Thomas H. MacDonald, Chief, Bureau of Public Roads.
George S. Webster, Past-President, Am. Soc. C. E.
Henry M. Crane, Society of Automotive Engineers.

Member Organizations:

American Society of Civil Engineers;
American Association of State Highway Officials;
American Concrete Institute;
American Institute of Consulting Engineers;
American Society of Mechanical Engineers;
American Society for Municipal Improvements;
American Society for Testing Materials;
Association of American State Geologists;
Bureau of Public Roads, U. S. Department of Agriculture;
Corps of Engineers, U. S. Army;

Engineering Foundation;
National Automobile Chamber of Commerce;
National Highway Traffic Association;
Society of Automotive Engineers.

Activities of the Director

In addition to conferences held in many States, with the object of organizing the work, the Director, as a representative of the Research Council, participated in the work of the group called together by Herbert Hoover, M. Am. Soc. C. E., Secretary of Commerce, to report on the letting of contracts for road building in the fall.*

Publicity.—Several papers have been presented before engineering bodies and Highway Conferences in the interest of Highway Research and future engagements include many important Highway Conferences to be held during 1922.

Washington Office.—The work at Washington, D. C., has been mainly directed to making contact with various organizations the activities of which touch the work of the Advisory Board, and in studying the useful field of the activities of the office of the Director.

Public Support

The project of the Advisory Board has been received favorably by the public, not only by highway engineers, but also by vehicle interests. Copies of the paper on "Program of Highway Research", presented before the Economic Conference, at the University of Maryland, on July 27th, 1921, was sent to the State highway officials, and gratifying expressions of interest and approval have been received.

Finances

The financial support of the Advisory Board is as follows:

The Research Council	$ 500
Engineering Foundation	1 000
Department of Agriculture through contract (In service from the Bureau of Public Roads, stenographic assistance, and recent assignment of half-time engineer for preparation of census of research.)	12 000
Connecticut Highway Department	1 000
Total	$14 500

Additional support is expected from several highway commissions.

Liabilities:

Salaries	$10 000
Travel expense (estimated)	2 500
Stationery, postage	500
Total	$13 000

A Survey of the Field of Research

Relation of Highway to Other Transport.—Freight is finding its way through new channels. Of the freight between Bakersfield and Los Angeles, Calif., 63% is carried over the well known Ridge Highway at 16 cents per ton-mile, rather than by the Southern Pacific Highway at 5 cents per ton-mile.

* *Proceedings*, Am. Soc. C. E., November, 1921, p. 873.

For the purpose of a view of the entire traffic situation and for a wise State and National policy, traffic studies are of special importance.

It is therefore necessary that the data underlying the economic disposition of traffic among the various agencies of transportation be obtained by trained research workers. Only in this way can one obtain an overhead view of the relation of highway transport to other existing agencies.

Economics.—There is an important service to be rendered by the highway engineer in locating his road so that the cost of operation will be reduced, these costs including charges, depreciation, replacement, maintenance of vehicle and road, etc. It is hoped that, within the course of a year, the cost of operation of vehicles, as determined by location and character of highways, will be fairly well determined. Professor T. R. Agg, M. Am. Soc. C. E., has accumulated a large amount of carefully determined data in connection with the work of the Experiment Station of the Iowa State College, and he is also directing work in New England, in which Harvard University, Yale University, Massachusetts Institute of Technology, Bureau of Public Roads, United States Army, Society of Automotive Engineers, and the highway commissions of Massachusetts and Connecticut are co-operating.

Professor N. W. Dougherty, Assoc. M. Am. Soc. C. E., of the University of Tennessee, has shown the value of a well planned program of regional studies of traffic. Here is an excellent field for local studies by universities.

Present traffic conditions should be studied and those in the near future must be envisaged before an intelligent program can be framed for the development of any region. In many cases, this policy involves the provision of permanent structures, location, and grading, to be used without paving until such time as the development of the country and the increased traffic justifies the paving of this roadbed. Instances are not wanting, however, in which the absence of paving under heavy traffic has brought about heavier costs, and a road impossible to maintain satisfactorily. Questions of the length of life of bonds for various types of roads and of the proportion of costs to be provided for by bonds and by current fees, can only be decided on the basis of physical facts and costs which, at present, are wanting.

Traffic Studies.—There is a live interest in traffic studies which have been planned in a number of States. The purpose, methods, and devices for measuring traffic are yet to be agreed on. Something more than the count of vehicles is necessary. The proportion of truck traffic and the weight of the vehicles should be known, in order that some estimate may be made of the proportion of the maintenance costs chargeable to truck traffic. One of the most complete traffic studies is that now under way in the State of Connecticut, in which not only the mechanical features of the traffic, but the commodity value, the origin, and destination are recorded. A study of the laws of development of traffic is now almost complete under the direction of Dean A. N. Johnson, M. Am. Soc. C. E., of the University of Maryland.

Such traffic studies are an important part of the economies of highway transport to which main question others are subsidiary. This cost arises from the road and the vehicle. It has been estimated that $12 are spent on the vehicle each year where $1 is spent on the road.

The most important sources of information on traffic are the States of Connecticut under Charles J. Bennett, M. Am. Soc. C. E., the State of Maryland under the direction of Dean A. N. Johnson, the State of Iowa under Professor Agg, the State of Minnesota under Mr. J. H. Mullen, and the information gathered during the recent studies of highways in California by the U. S. Bureau of Public Roads.

Operation.—The control of traffic, especially with reference to safety, is a paramount issue. A striking suggestion by Mr. J. H. Mullen, Chief Engineer of the Highway Department of the State of Minnesota, is that the speed on heavy passenger lines be limited to 40 miles per hour at the maximum and 25

miles per hour as a minimum between the hours of 8 A. M. and 8 P. M. This will force the truck traffic to the use of the roads in the night. The art of signaling highways needs study, and the recent paper by Mr. A. R. Hirst, of the State of Wisconsin, indicates the growing importance of this part of the operating field.

The control of public carriers using the highways through the fixing of rates and the regulation of service, seems to have been put in the hands of the public service commissions rather than highway commissions. The operating department in some States has snow removal problems equivalent to those of the railways.

Maintenance.—Maintenance costs, one of the most important elements entering into the economics of highway construction, have in the past not been properly determined and allocated. The choice of the type of road depends greatly on such data. Something more is needed than a total cost of maintenance from fence-to-fence or from shoulder-to-shoulder. The cost arising from the surface itself should be known, and whether this was a replacement or the result of a misfit of the type to traffic conditions. The U. S. Bureau of Public Roads will require a report on maintenance costs on all Federal Aid projects, according to a standardized system of accounting. In the course of time, reliable maintenance data may be secured. In the meantime, much can be learned from specific cases, particularly in those counties where foresighted individuals have properly analyzed maintenance costs.

A great deal of experimentation and research is needed to fix on the correct theory of maintenance of the various classes of roads.

Legislation.—Restrictive legislation on the weight of the vehicle should be based on a careful survey of existing conditions. A truck should go over State boundaries on main routes without being forced to reduce its load. It is said that only one-half of 1% of the traffic on the highways is in the form of vehicles over 5 tons in gross load. The data of research into highway economics are necessary for wise legislation.

Design of Road.—In the field of design the engineers are in a more favorable position. The main problem of research lies in the field of the load, the mechanical action of rigid and non-rigid slabs, and the properties of the subgrade.

Sub-Grade.—The design of the road should be related in some manner to the supporting power of the soil. A large volume of research is directed to the study of sub-soils and, particularly, to determine that element of the soil which determines its properties and to the treatment of sub-soils by drainage and the admixture of chemical additions. The most important agencies in this field are the U. S. Bureau of Public Roads, the Sub-Soil Committee under the chairmanship of Gen. E. I. Dupont, organized first as a committee of the now inactive Federal Highway Council, the work by Professor F. H. Eno, M. Am. Soc. C. E., of the Ohio State University, by Mr. Clifford Older, of the Illinois State Highway Department, and by the University of California. These researches include the mechanical and ultimate analysis of soils, instruments for determining bearing power and study of water movement and consequent volume changes. Studies are also under way in the U. S. Bureau of Public Roads for the protection of the shoulders and other means to preserve the moisture content of the sub-soil more uniformly. In California, the soil is improved by mixing in coarse aggregate. In some States a layer of tarred paper is placed on the sub-soil to prevent the entrance and egress of water which it is thought results in harmful volume changes of the concrete slab. When the studies under way are complete there should be within the year a fairly satisfactory account of the action of sub-soils, the means of testing them, and the implication which the data carry into the field of design. It is Mr. Older's observation that in the case of the soils of Illinois there is practically no supporting power under expected conditions, and that, therefore, the con-

crete slab must be designed as an overhanging cantilever with the load at the corner of the slab. The U. S. Bureau of Public Roads has treated some sub-soils by the admixture of additional materials, such as Portland cement, which apparently renders a plastic clay granular in its nature and destroys the plasticity. Experiments are under way by the California State Commission on treating adobe sub-soils.

Slab.—The width of surfacing is closely related to the findings of traffic studies and the habits of drivers. Multiples of 10 ft. are advocated by some. The Committee on Standards of the American Association of State Highway Officials will be the source of authority on questions of this kind.

As concerns the design of stiff slabs under a specified loading, there is an interesting field of scientific experimentation on a large scale. Some of the experimental roads may be listed as follows:

(1) The Bates Experimental Road, 2 miles long, built by the Illinois Highway Commission under the direction of Mr. Clifford Older, contains brick surface on concrete slabs of various mixtures and differently reinforced.

(2) A test road, 1 500 ft. long, oval in shape, built by the Columbia Steel Company, at Pittsburg, Calif., under the engineering direction of Messrs. Leonard and Aldrich, of San Francisco, and with the co-operation of the U. S. Bureau of Public Roads and the California Highway Commission. Contributions have been made by California automobile clubs. The construction includes concrete slabs of various thickness and shape, some with inverted curbs and variously reinforced, the steel varying from 20 to 69 tons per mile. This road was built in July, 1921, and first loaded November 9th, 1921, with 40 trucks, equivalent to the passage of 10 000 trucks per day. The sub-grade is adobe soil. Complete provision has been made for measuring volume changes due to temperature and for sub-soil moisture, and other pertinent data. Four tunnels, covered with 3½ ft. of rolled sub-grade, run transversely to the road. In these tunnels there is an autographic record of the deflections of the slab and the sub-grade due to the passage of traffic. The mechanical action of the slabs are determined by various positions of the truck under static and impact conditions.

(3) A reinforced concrete pre-cast slab road, in desert, built in 1920, at Casper, Wyo., is 2 400 ft. long. The units are 8 ft. long, 9 ft. wide, and 6 in. thick.

(4) An experimental concrete highway, 2 miles long, is under construction in Alexandria County, Virginia, under the direction of the U. S. Bureau of Public Roads. The sections of this highway are of various thicknesses and shapes, with various reinforcement. Preliminary scientific measurements have been made. This highway is subjected to normal farm traffic.

(5) An experimental road, of circular track, concrete base, and bituminous top, has been constructed by the U. S. Bureau of Public Roads at the Experiment Farm, Virginia. Various combinations of bituminous tops are to be tested under the action of a truck which is guided automatically.

Several roads have been built which contain variations in aggregate or reinforcing, as part of State systems, the data and description of which are not at present available.

There are also the remarkable investigations conducted by the U. S. Bureau of Public Roads, under Mr. A. T. Goldbeck, at the Experimental Farm near Washington, D. C.

When specimen tests are combined with service tests, the road designer should be in the near future in possession of data comparable to that at the disposal of designers of concrete buildings. It would seem that with the large mass of data that has been gathered and analyzed, the designer should be able to design a road slab with the certainty that he designs any other structure. The enterprise of the Columbia Steel Company, at Pittsburg,

Calif., should be encouraged and this Pittsburg road be continued with new sections.

Reinforced Roads.—The last word has not yet been said on the policy of reinforcing concrete roads. One extreme is a thick, heavy slab, massive enough to withstand such loads as are found in the State of Washington, namely, 20 tons of logs; the other extreme is a thin flexible slab which will deform under a load or under the action of frost and be brought back to its primitive shape by the elasticity of the reinforcing steel. No doubt, the adjustment in this respect would be determined by the condition of supply of materials and by a comparison of the maintenance costs of heavy concrete roads and thinner reinforced roads. Those who are designing experimental roads should have this element of research in mind. The reinforcement now generally used is only sufficient to hold together the broken sections of the concrete slab. Research is needed to determine the reinforcement which will be really effective under the various regional conditions of the United States.

Other Types.—In the rapid development of other types of roads, the experimental study of brick roads has been somewhat neglected, and the efforts of the National Association of Paving Brick Manufacturers to promote research comparable to that now being applied to other types of construction, should be welcomed.

Relation of Vehicle to Road.—Restrictive legislation on truck loads may result in a re-design of vehicles with new tire equipment or new relations of spring-borne and unsprung weight or multiple axles to carry maximum loads over highways with less destruction of the road. The recently proposed committee composed of representatives of the Society of Automotive Engineers and the Highway Engineers will consider the mutual relations of the vehicle to the road. The highway engineer also, with the automotive engineer, must conduct research into the effect of the various road surfaces on the operating cost, including gasoline consumption and tire wear, and the operating departments must also consider the road surface and alignment in relation to the statistics of accidents. Roads must also be evaluated from the standpoint of tractive effort and safety.

Construction.—One of the outstanding problems in the construction field, in the sub-division of materials, is the cause of surface waving, both in gravel and bituminous roads. Whether these surface waves or corrugations arise from methods of construction or maintenance, or from a lack of homogeneity in the materials, or lack of proper balance of filler and bituminous content, they certainly have come through the action of high-speed motor traffic. Whether this traffic operates to produce these waves by reason of spring action or engine impulse or otherwise is to be determined. The cost arising from this action is excessive. Research is needed to determine the cause and remedy. H. S. Mattimore, Assoc. M. Am. Soc. C. E., of the Pennsylvania State Highway Department, and Maj. F. S. Besson, of the District of Columbia, are active in research on the cause of waves in asphalt surfaces. The U. S. Bureau of Public Roads is making a special study of the corrugations of gravel roads, and is co-operating with the Asphalt Association in studying the causes of waving of asphalt pavements. A large number of samples have been secured from Washington, D. C., Baltimore, Md., New York City, Philadelphia, Pa., and Detroit, Mich.

A research into the efficiency of the operations of concrete mixers is much needed and also a further study of the product of central mixing plants.

The field of research on the fundamental principles of materials and on standardization of tests has been occupied for a great many years. These researches are well fitted to the ordinary university laboratory and are numerous. Perhaps special mention may be made of the following without doing injustice to the large number of devoted and able experimenters.

The work of Professor Duff A. Abrams, M. Am. Soc. C. E., of the Lewis Institute, Chicago, Ill., has made it now possible for expert testing engineers to duplicate tests of concrete cylinders in the laboratory with very close agreement. However, field tests of concrete cylinders scatter very widely even when they are made with great care by trained operators. At present, it may be asked if field tests of concrete cylinders in compression are indices of the concrete in the road. Are such tests a suitable basis for contractual relations? The practice of cutting cores from the hardened concrete roads is common, and although the returns are not sufficient to allow judgment, it does not appear at the present time that these cores are more uniform than the cylinders cast during the period of construction. The work of the Pennsylvania Highway Commission, the Illinois Highway Commission, the University of Illinois, and the Maryland Highway Commission, when brought together, will no doubt throw light on this vexing question.

A survey of supplies of road materials by which bidders on highway construction may know the available sources of acceptable material, quarry conditions, and freight rates, such as are conducted by Mr. H. S. Mattimore, of the Pennsylvania State Commission, result in an easily computable saving of money to the States. R. W. Crum, M. Am. Soc. C. E., Testing Engineer of the Iowa Highway Commission, and Professor M. O. Withey, of the University of Wisconsin, and the Purdue University Laboratory have given special attention to the use of available aggregates. The Kansas State Agricultural College and the Texas Highway Commission are both active in the field of development of materials of construction. The work of Mr. W. L. Schwalbe, in the study of consistency, at the University of Illinois, is likely to prove of great value. At Purdue University, a survey of road materials in the State is under way, and also studies of the test for surface hardness of concrete and the ability of plain concrete to undergo reversal stresses.

A little later, the Research Council expects to issue the results of a Census of Research in which the many valuable studies under way in the Experiment Stations of the various State universities will be listed and described. It is difficult to mention a few of these investigations in a paper of this kind without doing injustice to the large number of devoted research workers.

Research on structures, such as highway bridges, can only be mentioned, because the limits of space have already been exceeded.

Future Activities of the Director

During the past few months, the Director's activities have been personal, in education and promotion and in publicity. The assistance available in the U. S. Bureau of Public Roads probably will permit the Director to organize his office to some extent, to build up a permanent filing system, and to inaugurate the Census of Research and the Research Information Service. Research bulletins will be prepared. He will continue his visits to the highway commissions and to the universities to stimulate, co-ordinate, and find support for the research efforts of individuals. He will continue to keep in close touch with the activities of organizations that work in allied fields.

Activities of American Engineering Standards Committee

International Co-operation in Standardization

The American Engineering Standards Committee has just completed arrangements by which co-operation with the standardizing bodies in other countries will be made more effective. In doing this it has followed out the recommendations of the Unofficial Conference of the Secretaries of the National Standardizing Bodies held in London, England, in April, 1921.

In order that all standards shall be available to the industries of the various countries, it is planned that each National body will sell the approved standards of the other bodies. The American Engineering Standards Committee, at Engineering Societies Building, 29 West 39th Street, New York City, has available the publications of the standardizing bodies in Austria, Belgium, Canada, France, Germany, Great Britain, Holland, Sweden, and Switzerland.

Hereafter, the American Engineering Standards Committee will regularly exchange information with the foreign bodies as to the status of work on the various projects being undertaken under its auspices. This information will be limited to the indication of the stage of development of the projects, it being left in each case to the various sectional committees and sponsor bodies to decide to what extent they desire to exchange technical memoranda or drafts of standards. This exchange of information on the general progress of the work will, however, lay the basis for closer international co-operation as the need for this develops in special instances.

National Standardizing Bodies Organized in Japan and Norway

Standardization work in Japan has recently been given a great impetus by the organization of the Japanese Engineering Standards Committee. The main function of this Committee is to serve as a bureau for solving and initiating problems involving engineering standardization. The Committee consists of 70 members presided over by the Minister of the Department of Agriculture and Commerce acting as President, and a Vice-President, who is elected or appointed. The details of the work are handled by seven secretaries who are engineers of the Government Departments of Agriculture and Commerce, Communications, Railways, Military Engineers, and Naval Engineers. The work is being pushed with vigor, investigations already being under way on metals, woods, bricks, screws, electric wires, and electric motors.

In Norway, a National Standardization Committee has been organized by the Federation of Norwegian Industries. One of the first projects which is being taken up by the new Committee, after the necessary work on organizational problems, is the standardization of ship machinery and ship details.

There are now National standardizing bodies in the following fourteen countries: Austria, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden, Switzerland, and the United States.

American Engineering Standards Committee Approves Four Specifications

The American Engineering Standards Committee has approved as Tentative American Standard, the specifications of the American Society for Testing Materials for:

Cold-Drawn Bessemer Steel Automatic Screw Stock (A32-14).
Cold-Drawn Open-Hearth Steel Automatic Screw Stock (A54-15).
Methods of Chemical Analysis of Manganese Bronze (B27-19).
Methods of Chemical Analysis of Gun Metal (B28-19).

These specifications may be found in the 1921 volume of the American Society for Testing Materials Standards. Copies may also be obtained from the American Engineering Standards Committee, for 25 cents each.

American Railway Association and Steel Manufacturers Join American Engineering Standards Committee

Beginning with 1922, the American Railway Association (Engineering Division) and the Association of American Steel Manufacturers became member bodies of the American Engineering Standards Committee.

The Association of American Steel Manufacturers is an organization of forty iron and steel manufacturing companies. Its activities are limited to the standardization of rolling-mill practices and to the standardization and inspection of iron and steel products. The Association was organized in 1895. Its official representative on the American Engineering Standards Committee has not yet been designated.

The American Railway Association which speaks for practically all the steam railways of the United States, has four great technical branches, each having its own secretary, the Engineering and the Mechanical Divisions, and the Signal and the Telephone and Telegraph Sections. The Engineering Division which is intimately connected with the American Railway Engineering Association, the two organizations having the same officers, covers broadly the civil engineering activities of the railways. The standardization work in which the two associations are engaged, and which they have accomplished, is very extensive, both in scope and in amount. E. A. Frink, M. Am. Soc. C. E., of the Seaboard Air Line Railway, who is Chairman of the Standardization Committees of the two Associations, represents the American Railway Association (Engineering Division) on the American Engineering Standards Committee.

These two new member bodies bring the total number of National organizations represented on the American Engineering Standards Committee up to twenty-eight, and of representatives to fifty-two.

ACTIVITIES OF LOCAL SECTIONS*

Regular Meeting of the Colorado Section

The regular meeting of the Colorado Section was called to order at the Metropole Hotel, Denver, Colo., on January 9th, 1922; President A. N. Miller in the chair; Walter L. Drager, Secretary; and present, also, 9 members and 1 guest.

No quorum being present, the reading of the minutes and the transaction of business of the Section was postponed until the next regular meeting.

The Secretary presented correspondence from Engineering Council relative to the proposed bill in Congress, providing for the compulsory adoption of the Metric System, and the subject was discussed by those present.

An outline of the work of the Engineers' Building Committee appointed by Engineering Council was presented by the Secretary and was followed by considerable discussion.

Mr. James Munn addressed the meeting on "Progress at the Boulder Canyon Dam Site", describing the difficulties encountered by the engineers in drilling the foundation now in progress on the Colorado River.

Regular Meetings of Duluth Section

A meeting of the Duluth Section was called to order on November 21st, 1921, at 12:15 p. m.; President John L. Pickles in the chair; W. G. Zimmermann, Secretary; and present, also, 22 members and 3 guests.

The minutes of the October meeting were read and approved.

The Secretary presented letters from the Los Angeles Section and from the Secretary of the Service Engineers Committee at Washington, D. C., relative to the bill providing a commissioned status to sanitary engineers in the U. S. Public Health Service. After a brief discussion, it was decided, on motion, duly seconded, to appoint a committee of three to draft a resolution regarding this matter similar to that recently passed by the Los Angeles Section. Messrs. Coe, Darling, and McCool were appointed as such committee.

A paper by Maj. E. H. Marks, Corps of Engineers, U. S. A., on "Aerial Photography", was presented by the author.

Mr. W. H. Crego, Mining Engineer, also gave an informal talk on his experiences in exploration work at copper mines in the Belgian Congo, and a brief address on "Graphite and the Manufacture of Pencils" was delivered by Mr. J. E. Simpson, of the Joseph Dixon Crucible Company.

Meeting of December 19th, 1921

A meeting of the Duluth Section was called to order on December 19th, 1921, at 12:15 p. m.; President John L. Pickles in the chair; W. G. Zimmermann, Secretary; and present, also, 20 members and 1 guest.

The minutes of the meeting of November 21st, 1921, were read and approved.

The Secretary presented a number of letters in acknowledgment of the resolution adopted by the Section at its November meeting pertaining to

* For list of Local Sections, Officers, etc., see p. 175.

the matter of providing a commissioned status to sanitary engineers in the U. S. Public Health Service, which resolution had been sent to the United States Senators and Representatives from Minnesota.

A Symposium on "The Good of the Order" was opened by Messrs. Coe and Kelly, who were followed by a number of those present. The discussion which related to the best way of handling the meetings of the Section, and to its relation to Society matters in general, brought out the opinion that although some routine matters could be curtailed, any time spent on matters relating to the Society should be considered as time well spent, and that the Section should take a more active part in Society affairs by offering papers and discussions on engineering subjects for Society publication.

On motion, duly seconded, it was directed that arrangements be made to send an authorized representative of the Section to the Annual Meeting of the Society on January 18th, 19th, and 20th, 1922, in New York City.

Meeting of January 16th, 1922

A meeting of the Duluth Section was called to order on January 16th, 1922, at 12:15 p. m.; President John L. Pickles in the chair; W. G. Zimmermann, Secretary; and present, also, 22 members.

The minutes of the meeting of December 19th, 1921, were read and approved.

President Pickles stated that in compliance with the resolution at the December meeting, the Board of Directors had appointed Mr. O. H. Dickerson to represent the Section at the Annual Meeting of the Society in New York City.

Mr. W. H. Hoyt made a detailed and interesting report of the meeting of the Council of Federated American Engineering Societies at Washington, D. C.

A progress report from the Committee on City Planning in Duluth was presented by Mr. Coe.

Mr. N. B. Patton gave a brief address on the record and chart recently prepared by him bearing on temperatures and rainfall in Duluth during the past fifty years. The subject was discussed, and Mr. Patton's offer to present the whole matter in more detail at a later meeting was, on motion, duly seconded, unanimously accepted.

Mr. F. Hutchinson delivered an interesting address relative to his recent trip to South Manchuria, telling of the iron and coal deposits there and the proposed methods of mining them. On motion, duly seconded, Mr. Hutchinson was requested to continue the talk at some future meeting, and illustrate his remarks with lantern slides.

Meeting of Los Angeles Section

A regular meeting of the Los Angeles Section was held at the City Club, on January 11th, 1922; President R. J. Reed in the chair; F. G. Dessery, Secretary; and present, also, 48 members and 28 guests.

The President announced the appointment of the following Standing Committees: Program, City Planning, California Engineering Council, Public

Library, City Traffic Problems, Los Angeles County Regional Planning Conference, Representatives on Joint Technical Society, Sub-Structures in Coastal Waters, State Industrial Accident Commission, and Sewer.

Mr. H. Hawgood called attention to the meeting, at Pasadena, Calif., on January 16th, 1922, of the Consulting Board of the State Water Commission, outlining the work of the Commission and the necessity of co-operation in securing first-hand data on State water resources. On motion, duly seconded, President Reed appointed the following committee to represent the Los Angeles Section at this meeting: Messrs. A. L. Sonderegger, L. C. Hill, H. W. Dennis, S. B. Morris, and K. Q. Volk.

The meeting was addressed by J. A. Griffin, City Engineer of Los Angeles, who pointed out the necessity of immediate relief in regard to the sewage problem, illustrating his remarks with a number of photographs of the flooding of parts of the city with sewage during recent storms.

The speaker of the evening, Mr. Halbert P. Gillette, Editor of *Engineering and Contracting,* addressed the meeting on "The Engineer as a Political Economist", and at the conclusion of his address Mr. Gillette was given a rising vote of thanks.

Annual Meeting of the Nebraska Section

The Annual Meeting of the Nebraska Section was called to order at 4 P. M., on January 14th, 1922, at the Chamber of Commerce Building, Lincoln, Nebr.; President Rodman M. Brown in the chair; Homer V. Knouse, Secretary; and present, also, 19 members.

The minutes of the Thirty-ninth regular meeting were read and approved.

President Brown appointed the Tellers to canvass the ballot for Officers for 1922, and the Committee reported the following elections: President, William Grant; Senior Vice-President, George T. Prince; Junior Vice-President, H. H. Tracy; and Secretary-Treasurer, Homer V. Knouse.

The Secretary called attention to articles in recent issues of the *Omaha World-Herald,* in which attacks were made on the work of the Federal Bureau of Public Roads and the Department of Public Works of Nebraska, and to the unfairness of the statements made therein. After some discussion, on motion, duly seconded, the President was instructed to appoint a Committee on Resolutions. During the discussion of this motion, it was brought out that it was the feeling of the meeting that the resolutions should condemn the practice of taking the unsupported word of untrained and prejudiced observers in attacks on professional engineers.

Mr. W. H. Campen presented for discussion the question of standard specifications for municipal and State work as applied to the building of highways, and the subject was discussed at some length.

The character of programs for future meetings of the Section was also discussed, and without formal action it was agreed that at future meetings, if possible, papers should be presented by members of the Section, as well as addresses or papers by members of the Society or others not local residents.

The Treasurer presented his Annual Report.

The Committee on Resolutions presented a report which was generally discussed, and, on motion, duly seconded, referred to a later session for further action.

After an adjournment for dinner, the meeting was called to order at 8 P. M., at the Grand Hotel; President Brown in the chair; Homer V. Knouse, Secretary; and present, also, 22 members and 3 guests.

President Brown presented the Annual Address, his subject being "The Builder".

Mr. W. E. Hardy, a member of the State Capitol Commission, presented an address on "The New Capitol Building", following which a vote of thanks was extended to him.

The report of the Committee on Resolutions was presented for consideration and, on motion, duly seconded, was adopted.

President-elect Grant was escorted to the chair and addressed the meeting on the work of the Section. He also announced that the Entertainment Committee, Messrs. Letton, Green, and Bates, would be continued to arrange for the February meeting, and in this connection Mr. Letton stated that the February meeting would be addressed by Mr. E. S. Jarrett, who would describe the design of the foundations of the new State Capitol.

On motion, duly seconded, the President was instructed to appoint a committee of five to make recommendations in regard to standardizing specifications and to conduct such investigations as were deemed necessary.

R. E. Edgecomb, Chief Engineer of the Building Department of the City of Omaha, announced that the final preliminary draft of the new Building Code for the City of Omaha would be issued shortly, and requested the President to appoint a committee of the Section to review the proposed Code and make recommendations. The President subsequently appointed Messrs. Latenser, Vogel, and Bruce as such committee.

New York Section Considers Methods of Traffic Handling

The second regular meeting of the New York Section, which was held on January 11th, 1922, in the Engineering Societies Building, considered the subject "Traffic Handling—Its Engineering as Well as Regulatory Aspects"; President Nelson P. Lewis in the chair; J. P. J. Williams, Secretary; and present, also, about 95 members and guests.

The reading of the minutes of the previous meeting was dispensed with, on motion, duly seconded, and carried.

The Secretary announced the results of the questionnaire in regard to holding sub-section group meetings supplementary to the regular monthly meetings, to discuss technical problems in various fields, and read the names of 42 applicants for membership in the Section, obtained as a result of the appeal issued by the Membership Committee.

The subject of the evening was introduced by Messrs. Amos Schaeffer, Consulting Engineer to the President of the Borough of Manhattan, and E. P. Goodrich, Consulting Engineer, New York City, and was discussed by Messrs. Robert Grier Cooke, President of the Fifth Avenue Association; John

F. O'Brien, Inspector, New York Police Department, representing Dr. John A. Harriss, Special Deputy Commissioner of Police in charge of traffic regulation, who was unable to be present; Clifford M. Holland, Chief Engineer, New York State Bridge and Tunnel Commission and New Jersey Interstate Bridge and Tunnel Commission; A. T. Warner, Traffic Engineer, Public Service Railway Company, Newark, N. J.; D. L. Turner, and John P. Fox, Secretary of the Murray Hill Association.

Mr. Schaeffer presented the engineering aspects of the subject, giving results of traffic counts to indicate the seriousness of the problem at certain congested points in New York City. He stated that the opening of the Park Avenue Viaduct, cited as a striking example of how engineering can be applied to the solution of problems of traffic congestion, had resulted in a decrease in the traffic passing 42d Street on Fifth Avenue, a decrease of about 18% in the traffic on Madison Avenue, and an increase of 168% in the traffic on Park Avenue between 34th and 35th streets. These figures were based, he said, on traffic counts before and about six months after the Viaduct was opened, the traffic on the latter being then 2 098 vehicles at the maximum hourly count, or 8.74 per lane of traffic per minute—the greatest intensity found on any of the thoroughfares under consideration. He considered this a most successful method of relieving congestion, and stated that plans were made to improve it still further by opening Depew Place on the easterly side of the Grand Central Station.

Mr. Schaeffer described the plans made to eliminate the grade crossing at 42d Street and Fifth Avenue, and the proposed underground sidewalks to extend from Grand Central Station to a point west of Fifth Avenue. He discussed in detail the difficulties of the problem of handling the traffic to be poured into a congested district when the new Vehicular Tunnel is completed. He stated that the City had been widening roadways when congested streets are repaved, and also replacing the 6-ft. curves at curb intersections by 12-ft. curves, and concluded by describing the waste of roadway space caused by elevated railway columns and the effects of granite block *versus* sheet asphalt pavements.

Mr. Cooke discussed the traffic problem of Fifth Avenue from the viewpoint of the merchant, and stated that it was through Dr. Harriss that the suggestion of a signaling system first proposed nine years ago by the Fifth Avenue Association was put into operation. This system of simultaneous movement by blocks controlled by lights had increased the vehicular traffic by 75%, he said, and had demonstrated its efficiency by actual test. He felt that it would soon be necessary to limit the kind of vehicles on the Avenue still further, and probably reduce the number of buses. He stated that there had been placed before the Board of Aldermen by the Association an ordinance which practically prohibits parades, except when business houses are closed.

Mr. Goodrich showed a working model and illustrated the possibilities of obtaining continuous movement by a "platoon system" of control of traffic movement, by which he claimed that double the present efficiency could be obtained. This system, he pointed out, would have the advantage over the present system in that it would not stop and start the lanes of moving vehicles,

but would keep them moving continuously in groups, separated by a time interval on both north and south and east and west streets, all to be regulated by an electrically controlled semaphore system. He also emphasized the advisability of such mechanical control for the present system, and stressed the need for greater restrictions in regard to parking and unloading at the curb.

Inspector O'Brien described briefly the growth of traffic regulation by the Police Department since its inception in 1903, until, at the present time, there are 1 547 men in the traffic squad. He advocated the elimination of the left-hand turn, and pointed out the difficulties in carrying out any such theoretical plan as that proposed by Mr. Goodrich. He said it was planned to extend the light system of control to parts of the Bronx, the Grand Concourse, and Bedford Avenue, Brooklyn, and described the method of controlling and diverting theater traffic in the Times Square District.

Mr. Holland explained the economic requirements which limited the width of roadway in the new Vehicular Tunnel, and described the plans for a wrecking crew to remove immediately any obstructing vehicle stalled in the tunnel. He cited figures on traffic intensity on the Manhattan Bridge, showing that maximum intensity occurred at a speed of about 12 miles per hour.

Mr. Warner gave in detail the difficulties of the street car companies in handling peak traffic, describing the many proposals for decreasing time consumed in loading passengers. He believed the motor bus had its place as a feeder or auxiliary to rapid transit. He advocated the adoption of staggered working hours for industries located in a given section so that the peak load would be relieved and greater comfort secured for all concerned.

Mr. Turner mentioned the plan he had proposed for a moving platform on 42d Street, to run from river to river, all trolley car tracks to be removed, and underground sidewalks provided for the whole width of the city at that point. He also mentioned his plan to reduce surface car trackage about 40%, by setting aside four longitudinal thoroughfares for vehicular traffic only, and advocated the adoption of police regulations to keep vehicles off the car tracks entirely during rush hours and prohibiting parking on certain streets at that time.

Mr. Fox strongly endorsed the "platoon system" proposed by Mr. Goodrich and showed how it conformed with the fundamental principle of railroad operation in that it kept the traffic in continuous movement in place of alternate stopping and starting.

Meeting of the Pittsburgh Section

A regular meeting of the Pittsburgh Section was held on January 30th, 1922, at the Hotel Chatham; Vice-President J. L. De Vou in the chair; Nathan Schein, Secretary; and present, also, 30 members.

The minutes of the previous meeting were read and approved.

The Secretary presented a communication from the Parent Society relative to information as to the sentiment of this District either for or against the Society joining the Federated American Engineering Association. On motion, duly seconded, the following resolution was unanimously adopted:

"That it is the sense of this meeting that the Parent Society join the Federated American Engineering Association."

On motion, duly seconded, the Secretary was instructed to send out a letter-ballot to the members of the Section to ascertain their sentiments relative to the Federated American Engineering Association, and also stating the action of this meeting.

Mr. J. M. Daniels, Secretary of the Pittsburgh University Student Chapter of the Society, addressed the Section, requesting aid in furnishing speakers for the Student Chapter meetings. On motion, duly seconded, this request was referred to the Executive Committee.

Messrs. T. J. Wilkerson and R. Khuen made a report on the Annual Meeting of the Society.

On account of the absence of President John N. Chester, the discussion of the possibility of reading papers before the Section was postponed, and a special meeting was requested to be held later for such discussion.

Dr. T. S. Baker, Acting President of the Carnegie School of Technology, addressed the Section on "French and German Relations", following which there was a general informal discussion of the subject by those present.

On motion, duly seconded, a rising vote of thanks was extended Dr. Baker for his address.

Meetings of the Portland Section

A meeting of the Portland Section was held on November 18th, 1921, at the University Club; President M. E. Reed in the chair; C. P. Keyser, Secretary; and present, also, 26 members and 9 guests.

The minutes of the meeting of October 28th, 1921, were, on motion, duly seconded, ordered passed for future reading.

On motion, duly seconded, the Secretary was instructed to send a letter of thanks to the Associated General Contractors for entertaining the members of the Section at dinner on November 2d, 1921.

The speaker of the evening, Mr. William H. Lewis, addressed the meeting on "The Construction of Embankments, Dams, and Stadiums by Hydraulic Sluicing", illustrating his remarks with lantern slides.

Meeting of December 16th, 1921

A dinner meeting of the Section was held at the University Club on December 16th, 1921, at which the members of the Portland Chapter of the Associated General Contractors were invited guests.

Following the dinner, the meeting was called to order by President M. E. Reed; C. P. Keyser, Secretary; and present, also, 28 members and 26 guests.

President Reed introduced Mr. Ellis F. Lawrence, who gave an outline of the purpose and objects of the recently instituted Building and Construction Association of Oregon. Mr. Lawrence was followed by Messrs. Mason and Dougan, who offered brief discussions on the subject.

Mr. A. R. Nichols presented a paper entitled "The Relation of the Smith-Hughes Law to Industry", in which he showed that skilled mechanics and artisans are decreasing in numbers, that there is virtually no system of ap-

prenticeship in the United States, and what the Government and State, in co-operation under this Law, are doing to train young men in the trades.

Following this paper, the meeting was thrown open to an informal discussion in which Messrs. Mason, Muir, McDougall, Kern, Griswold, and Welton took part. During this discussion, a suggestion was made that a committee be appointed to revise and standardize specifications, and President Reed stated that he would take action later on the suggestion.

Annual Meeting of the Portland Section

The Annual Meeting of the Portland Section was held on January 13th, 1922, at the University Club; President M. E. Reed in the chair; C. P. Keyser, Secretary; and present, also, 34 members and 1 guest.

The minutes of the meetings of October 28th, November 18th, and December 16th, 1921, were read, and subject to the addition of a record of the organization of the proposed board of works for the 1925 Fair, which was outlined by Mr. Stevens at the November 18th meeting, were approved.

The Annual Reports of the Treasurer and Secretary were presented, and on motion, duly seconded, were adopted, and ordered recorded with the minutes.

Mr. D. W. Cole reported for the Committee on Aggression of Certain Interests in National Parks that the cause of the Committee had virtually dissolved before the Committee had taken action.

The Secretary presented a communication from F. H. Murphy, Secretary of the Oregon Technical Council, advising that the term of Mr. J. C. Stevens as a delegate from the Section had expired, and asking that a successor be appointed. On motion, duly seconded, Mr. Stevens was re-appointed to serve for 1922 and 1923. On motion, duly seconded, the President and Secretary were named *ex-officio* alternates to the delegates.

It was moved and seconded that the dues for the year 1922 be fixed at $2.50 and that the Secretary be instructed to send out notices to all members in Oregon. On motion, duly seconded, an amendment to this motion, that action be held in abeyance pending a report from New York as to the ruling of the Board of Direction in the matter of allocated dues to the Section, was carried. The original motion was then put and carried.

On motion, duly seconded, it was decided to appoint a committee of three to revise the Constitution of the Section, and the Chair ruled that the appointment of the committee would be the duty of the incoming President.

The following officers for 1922 were declared elected: F. M. Randlett, President; W. G. Brown, Second Vice-President; C. N. Bennett, Treasurer; and C. P. Keyser, Secretary.

Mr. George E. Goodwin, Chief Engineer of the National Parks, gave an interesting talk on his work.

The meeting was also addressed by Mr. G. A. Kyle, who gave an entertaining account of some of his work and experiences in railroad building in China; Mr. Roy A. Klein who reviewed the work of the Highway Commission of Oregon since its inception, and indicated the scope of its program by maps and charts; and Prof. Stuart Sims who spoke briefly on the work of the Student Chapter of the Society at the Oregon Agricultural College.

Joint Meeting of the Providence Section and the Municipal Section of the Providence Engineering Society

A Joint Meeting of the Providence Section and the Municipal Section of the Providence Engineering Society was held on December 27th, 1921.

Mr. George Henderson, Civil Engineer, Rhode Island State Board of Public Roads, gave an informal talk on the State roads of Rhode Island, stressing particularly the details and application of the Federal Aid System for roads; the practice in Rhode Island of selecting a durable type of pavement for each road, which will utilize, as far as possible, materials to be found in its vicinity; and the practice in Rhode Island of building roads on the basis of "pay as you go" and building bridges by bond issues.

Regular Meeting of St. Louis Section

A regular meeting of the St. Louis Section was called to order at the American Hotel, on December 27th, 1921; President E. B. Fay in the chair; William C. E. Becker, Secretary; and present, also, 20 members.

The minutes of the meeting of November 28th, 1921, were read and approved.

The President announced the appointment of the Program Committee as follows: Messrs. S. Bent Russell, Chairman, W. W. Horner, and J. W. Skelley.

The death of Hiram Phillips, M. Am. Soc. C. E., was announced by President Fay, who also stated that a telegram had been sent to Mrs. Phillips expressing the sympathy of the Section.

On motion, duly seconded, the President was instructed to appoint a committee to prepare a resolution to the memory of Mr. Phillips and also to prepare a memoir of him for publication in the *Proceedings* of the Society. The President subsequently appointed as such Committee, Messrs. E. E. Wall, Chairman, J. T. Garrett, and S. Bent Russell.

The proposed amendments to the Constitution of the Society to be considered at the Annual Meeting were then discussed, and, on motion, duly seconded, the amendments to Articles II, IV, and VII, pertaining to "Membership", "Dues", and "Nomination and Election of Officers", respectively, were approved by the Section.

On motion, duly seconded, it was decided that no action should be taken by the Section on the other proposed amendments.

On motion, duly seconded, it was decided that if only one meeting of the Society could be held in St. Louis, in 1922, that preference be given to the Annual Convention.

Mr. E. E. Wall announced that a fund was being raised by subscription from members of the Society for the purchase of a bust of the late James Buchanan Eads, F. Am. Soc. C. E., to be placed in the Hall of Fame of New York University. The discussion following this announcement indicated that the subscription would meet with the hearty approval of the members of the Section.

The meeting was addressed by J. W. Woermann, M. Am. Soc. C. E., who spoke on the activities of the Chicago Section and other Engineering Societies.

Meetings of the San Diego Section

A meeting of the San Diego Section was held on October 18th, 1921, at which, in addition to the routine business, Mr. George Cromwell gave an interesting outline of the results of studies and investigations relating to the future development of the water supply system of San Diego.

At the meeting which was held on November 15th, 1921, the speaker was Mr. R. M. Morton, who discussed the highway system of San Diego County now under construction and various features of highway construction in general.

A special meeting of the Section was held on December 12th, 1921, coinciding with the hearing on the Boulder Canyon Project for the control of the Colorado River, which was held in San Diego by the Secretary of the Interior and Arthur P. Davis, Past-President, Am. Soc. C. E., Director of the U. S. Reclamation Service.

After a brief discussion of Society affairs, Mr. Davis outlined the salient features of the Boulder Canyon Project and the future development of the Southwest which would be made possible thereby.

The meeting was also addressed by Messrs. George G. Anderson and C. E. Grunsky, who related some of the early history connected with the development of the Imperial Valley, and J. C. Allison, M. Am. Soc. C. E., a resident of the Imperial Valley, gave an account of the work now under way for river control and flood protection in the Valley.

This meeting of the Section was an open meeting and was attended by a number of engineers residing in San Diego and its vicinity.

EMPLOYMENT SERVICE OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

An Engineering Societies Service Bureau was established December 1st, 1918, as an activity of Engineering Council, managed by a board made up of the Secretaries of the four Founder Societies, funds for its maintenance being provided by these Societies. On January 1st, 1921, this Bureau was taken over by The Federated American Engineering Societies and is now known as the Employment Service of that organization. It is co-operating with engineering organizations in all parts of the country and is desirous of increasing such co-operation by working with local engineering associations and clubs. Members of the American Society of Civil Engineers who desire to register should apply for further information, registration forms, etc., to Walter V. Brown, Manager, Engineering Societies Building, 29 West 39th Street, New York City. In order to be included in the list published in *Proceedings,* copy must be received on or before the first Wednesday of each month. All communications should be addressed to Mr. Brown.

EMPLOYMENT BULLETIN

POSITIONS AVAILABLE

RESEARCH GRADUATE ASSISTANTSHIPS in Engineering Experiment Station, University of Illinois. Open to graduates of approved American and foreign universities and technical schools prepared to undertake graduate study in engineering. physics, or applied chemistry. Appointment must be accepted for two consecutive collegiate years, after which, if all requirements have been met, the degree of Master of Science will be conferred. Work of the Department will require about half the time of the Research Graduate Assistant, the remainder being available for graduate study. Nominations to positions are made from applications to the Director of the Engineering Experiment Station each year not later than March 1st, and are based on character, scholastic attainments, and promise of success in principal line of research to which candidate proposes to devote himself, preference being given to those with some practical engineering experience following undergraduate work. Appointments are made in Spring and become effective following September 1st. Vacancies are filled at other times. Assistantships carry an annual stipend of $600 and freedom from all fees, except matriculation and diploma fees. For adidtional information address, The Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

ENGINEER to sell service. Should know building alteration and repair work. Application by letter only. Commission basis. V–127.

MEN AVAILABLE

GRADUATE CIVIL ENGINEER, Dr. Eng., M. Am. Soc. C. E. Specialist in hydrography, river and harbor improvements, port works and jetty construction. Can design and execute the works indicated. Has had experience in Mexico, Guatemala, Panama, and Brazil. Is familiar with Portuguese, Spanish, and French languages. Best of references furnished. CE–299.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E., age 31, married. College graduate. Ten years' experience covers design, construction, estimates, and executive authority on steel and reinforced concrete structures, municipal and highway design. Available on short notice. CE–300.

CIVIL AND HIGHWAY ENGINEER, Assoc. M. Am. Soc. C. E., age 31. Graduate Civil Engineer. Desires position with consulting engineer, engineering firm, or as highway contractor's engineer. Experience of 6½ years, in charge of all kinds of surveys, drafting, designs, and estimates, and of construction of highways and bridges on city, county, and State work. Four years of this time on county and State highway work as Resident and Assistant Engineer. Available at once. Location in East preferred. CE–301.

HYDRAULIC ENGINEER AND SUPERINTENDENT, M. Am. Soc. C. E. Graduate Civil Engineer. Twenty-six years' experience as Engineer and Superintendent, water, sewer, electric railway, and hydro-electric power development. Last four years with War Department as Major, Engineers, and as civilian employee in charge of maintenance and operation of utilities. Desires work with power company after February 1st. Can qualify for exploration, design, construction, or appraisal, and will go anywhere. CE–302.

CIVIL ENGINEER, M. Am. Soc. C. E. College graduate. Twenty-six years' experience on railroad location and construction public building design and construction, hydraulic and power plant construction, municipal work, and concrete construction. Efficient executive and organizer. Excellent record and references. Desires responsible position with banking house or financial interests for making investigations, reports, appraisals, estimates. Will consider any proposition, engineering or associated work. Now employed, but available on short notice. CE–303.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E., age 30, married. Six years' on industrial construction, two years on railroad construction, one year overseas as 1st Lieutenant, Engineers. Available at once. CE–304.

MECHANICAL AND CIVIL ENGINEER, Assoc. M. Am. Soc. C. E., and M. I. Mech. Engrs., Great Britain, age 47, married. Twenty-five years' works and office experience in United States and Europe. Served as chief designer, chief draftsman, and master mechanic with large firms of shipbuilders, steel manufacturers, and general engineers. Head instructor in vocational classes. Desires position anywhere, at once. CE–305.

CIVIL ENGINEER, Jun. Am. Soc. C. E. Technical graduate. Six years' experience on water-works, building, and highway construction; reinforced concrete design. Location immaterial. Available on short notice. CE–306.

EXPERT STRUCTURAL ENGINEER wishes position in charge of structural work for leading architect, engineer, or industrial corporation, in or near New York City. Salary, $4 000. CE–307.

ENGINEER, Jun. M. Am. Soc. C. E., age 26, married. More than five years' experience, highways, bridges, sewers, reinforced concrete, topographic mapping, and surveying, includes office computing, and drafting, charge of field work, and field inspection. Desires any permanent connection with good possibilities for advancement. Eastern States preferred. CE–308.

ENGINEER AND CONSTRUCTOR, M. Am. Soc. C. E., age 44. Twenty-four years' experience as engineer, superintendent, and executive in the United States, Alaska, Canal Zone, and Peru, principally in charge of city improvements, river and harbor improvements, dredging, hydro-electric construction, irrigation, shipbuilding, dams, buildings, etc. Speaks Spanish. CE–309.

CIVIL-MECHANICAL SUPERVISING ENGINEER, Assoc. M. Am. Soc. C. E., age 35. Well varied experience in power, hydraulic, and industrial work, both engineering and construction. Record of responsible and executive connections with well-known organizations; thorough business training. Experience throughout the country; now in Chicago District. CE–310.

ANNOUNCEMENTS

The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

PROGRAM FOR MONTHLY SOCIETY MEETINGS

The Publication Committee announces the following tentative program covering the monthly meetings up to the summer recess. In each case, the meetings will be held on the Fifth Floor of the Engineering Societies Building, 33 West 39th St., New York City, at 8 P. M., on the days noted.

March 1st, 1922.—A regular monthly business meeting will be held, at which time the ballot on the Proposed Amendments to the Constitution will be canvassed, followed by the formal presentation of the paper, "Siphon Spillways", by G. F. Stickney, M. Am. Soc. C. E. This paper appears in the current issue of *Proceedings.*

April 5th, 1922.—Paper by Gustav Lindenthal, M. Am. Soc. C. E., entitled "The Continuous Truss Bridge Over the Ohio River at Sciotoville, Ohio, of the Chesapeake and Ohio Northern Railway", to be published in March *Proceedings,* and presented by the author for discussion.

May 3d, 1922.—Paper by Arthur T. Safford, M. Am. Soc. C. E., and Edward Pierce Hamilton, Esq., entitled "The American Mixed Flow Turbine and Its Setting", to be published in April *Proceedings,* and presented by Mr. Safford for discussion.

June 7th, 1922.—Informal discussion on "Tentative Specifications for Steel Railway Bridges", submitted as a Progress Report of the Special Committee on Specifications for Bridge Design and Construction, and published in the December, 1921, *Proceedings.*

SPRING SOCIETY MEETING

At its meeting on January 20th, 1922, the Board of Direction adopted the plan of holding Spring and Fall Meetings in different parts of the country to consider National economic problems in their broader phases. The first meeting of this series has been scheduled to be held in Dayton, Ohio, on April 5th and 6th, 1922, on the subject of "Flood Problems". A detailed program will be mailed to the membership in due course.

LIBRARY BOOK LOANS

The Library Board of the Engineering Societies Library has adopted rules authorizing the Director of the Library to lend to members of any Founder Society any duplicate books in the Library, subject to the following rules:

1.—Duplicate books may be lent to members of Founder Societies or of any other societies that contribute to maintain the Library.

2.—Books will be lent for twenty-eight days, including time in transit.

3.—Five cents a day will be charged for each book kept longer than twenty-eight days.

4.—Borrowers shall be responsible for books borrowed, and shall pay shipping and insurance charges from and to the Library.

The Library has several thousand volumes that can be lent under this authorization. These include a considerable number of textbooks, reports, etc., of various dates. Periodicals are not included, as the cost of storing duplicate sets seems prohibitive and individual articles can be photoprinted at little expense. The collection is being increased regularly by the addition of any suitable duplicates received by the Library. Members are invited to present any books of permanent value for this purpose, which they can spare from their libraries. It is hoped that in time the collection may become adequate to meet the usual needs of members by providing any standard book required for a short time.

No catalog has been published, although it is hoped that one may be, when the collection becomes extensive enough to warrant doing so. Until that time, the Director will be glad to receive requests and report whether the books are available or not.

SEARCHES IN THE LIBRARY

As the Library of the American Society of Civil Engineers has been merged in the Engineering Societies Library, requests for searches, copies, translations, etc., should be addressed to the Director, Engineering Societies Library, 29 West 39th Street, New York City, who will gladly give information concerning the charges for the various kinds of service. A more comprehensive statement in regard to this matter will be found on page 21 of the Year Book for 1921.

SECOND MEETINGS OF THE MONTH

Under authority given by the Board of Direction at its meeting of August 9th, 1920, the Acting Secretary has made an arrangement with the New York Section whereby the latter will take over the second meeting of the month, and will thus hold its own meetings on the third Wednesday of each month, except January and May, when they are held on the second Wednesday.

The programs of the New York Section* are similar to those heretofore offered by the Society's Committee on Second Meeting of the Month, and it is understood that all members of the Society are invited to attend the meetings regardless of whether or not they may be members of the Section. This arrangement gives each member the same privilege of attendance at meetings which he has heretofore enjoyed, and is deemed especially desirable since there has been considerable doubt as to the attendance that might develop at the several meetings if three were held in each month.

PAPERS AND DISCUSSIONS

Members and others who take part in the oral discussions of the papers presented are urged to revise their remarks promptly. Written communications

* *Proceedings*, Am. Soc. C. E., October, 1921, p. 803.

from those who cannot attend the meetings should be sent in at the earliest possible date after the issue of a paper. Written discussion on a given paper will be closed three months after the paper has been published, so that the author's closure can be printed four months after the paper.

All manuscripts submitted for publication should preferably be typewritten, and always double spaced. Drawings and diagrams should be on separate sheets, drawn to a scale suitable for about one-half to one-fourth reduction.

All papers accepted by the Publication Committee are classified by the Committee with respect to their availablity for discussion at meetings.

Papers which, from their general nature, appear to be of a character suitable for oral discussion, will be set down for presentation to a future meeting of the Society, and, on these, oral discussions, as well as written communications, will be solicited.

All papers which do not come under this heading, that is to say, those which from their mathematical or technical nature, in the opinion of the Committee, are not adapted to oral discussion, will not be scheduled for presentation to any meeting. Such papers will be published in the same manner as those which are to be presented at meetings, but written discussions only will be requested for subsequent publication in *Proceedings* and with the paper in the volumes of *Transactions.*

The Board of Direction has adopted rules for the preparation and presentation of papers, which will be found on page 36 of the Year Book for 1921.

LOCAL SECTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Section (Constitution Approved by Board, 1905).

Thomas H. Means, President; H. D. Dewell, Secretary-Treasurer, 503 Market Street, San Francisco, Cal.

Bi-monthly meetings are held at 6 P. M., at the Engineers' Club, 57 Post Street, on the third Tuesday of February, April, June, August, October, and December, the last being the Annual Meeting. Informal luncheons are held at noon, every Wednesday, at the Engineers' Club. All members of the Society will be gladly welcomed.

Colorado Section (Constitution Approved by Board, 1909).

A. N. Miller, President; Thomas H. Olds, Acting Secretary-Treasurer, First National Bank Building, Denver, Colo.

Meetings are held on the second Monday of each month, except July and August, usually preceded by an informal dinner. Weekly luncheons are held on Wednesday, at 12.30 P. M., at Daniels and Fisher's. Visiting members of the Society are urged to attend.

Atlanta Section (Constitution Approved by Board, 1912).

William C. Spiker, President; Frederick H. McDonald, Secretary-Treasurer, 1530 Healey Building, Atlanta, Ga.

Informal luncheons are held on the second Tuesday of each month, at 1.00 P. M., at the Ansley Hotel, to which visiting members of the Society are welcome. Visitors desiring information will telephone the Secretary.

Baltimore Section (Constitution Approved by Board, 1914).

Ezra B. Whitman, President; George S. Robertson, Sr., Secretary-Treasurer, 1628 Linden Avenue, Baltimore, Md.

Buffalo Section (Constitution Approved by Board, 1921).

A. L. Johnson, President; Bruce L. Cushing, Secretary-Treasurer, 80 West Genesee Street, Buffalo, N. Y.

Central Ohio Section (Constitution Approved by Board, 1921).

F. H. Eno, President; H. F. Schryver, Secretary, 405 New York Central Building, Columbus, Ohio.

Meetings are held at the rooms of the Engineers' Club of Columbus in the Southern Hotel. The Annual Meeting is held on the second Friday of November and at least two other meetings are held each year, the dates of which are designated by the Board of Direction of the Section.

Cincinnati Section (Constitution Approved by Board, 1920).

Edgar Dow Gilman, President; Alphonse M. Westenhoff, Secretary, 13 East Third Street, Cincinnati, Ohio.

Cleveland Section (Constitution Approved by Board, 1915).

A. V. Ruggles, President; George H. Tinker, Secretary-Treasurer, 516 Columbia Building, Cleveland, Ohio.

Regular meetings are held on the second Wednesday of each month, at 12.15 P. M., in the rooms of the Section, Hotel Winton. Luncheon is served, and all visiting members of the Society are invited to attend.

Connecticut Section (Constitution Approved by Board, 1919).

William J. Backes, President; Clarence M. Blair, Secretary-Treasurer, 785 Edgewood Avenue, New Haven, Conn.

The Annual Meeting is held in April; fortnightly meetings alternate between Hartford and New Haven, Conn. These meetings are informal luncheon gatherings, held usually at noon on Saturday. Members are privileged to invite guests regardless of their affiliation as engineers.

Detroit Section (Constitution Approved by Board, 1916).

H. H. Esselstyn, President; Alex. Linn Trout, Secretary-Treasurer, 2974 Field Avenue, Detroit, Mich.

Regular meetings are held on the second Friday of December, April, and October, the last being the Annual Meeting.

District of Columbia Section (Constitution Approved by Board, 1916).

Gratz B. Strickler, President; James H. Van Wagenen, Secretary-Treasurer, 2001 Sixteenth Street, N. W., Washington, D. C.

Duluth Section (Constitution Approved by Board, 1917).

John L. Pickles, President; Walter G. Zimmermann, Secretary, 203 Wolvin Building, Duluth, Minn.

Regular meetings are held at noon on the third Monday of each month, usually at the Kitchi Gammi Club, to which visiting members of the Society will be welcomed. The Annual Meeting is held on the third Monday in May.

Illinois Section (Constitution Approved by Board, 1916).

A. J. Hammond, President; W. D. Gerber, Secretary-Treasurer, 133 West Washington Street, Chicago, Ill.

Regular meetings are held on the second Monday of March, June, September, and December, the last being the Annual Meeting.

Iowa Section (Constitution Approved by Board, 1920).

J. H. Dunlap, President; R. W. Crum, Secretary, Care, Iowa State Highway Commission, Ames, Iowa.

Kansas City (Mo.) Section (Constitution Approved by Board, 1921).

John V. Hanna, President; Henry C. Tammen, Secretary-Treasurer, 1012 Baltimore Avenue, Kansas City, Mo.

Regular meetings of the Section are held on the first Tuesday of March, June, September, and December, the last being the Annual Meeting. The members of the Kansas City Engineers' Club meet at luncheon at the University Club every Tuesday from 12 M. to 2 P. M., and all members of the Society are invited to attend these luncheons.

Kansas Section (Constitution Approved by Board, 1920).

L. E. Conrad, President; Frank S. Altman, Secretary-Treasurer, 1114 Garfield Avenue, Topeka, Kans.

Los Angeles Section (Constitution Approved by Board, 1913).

Ralph J. Reed, President; Floyd G. Dessery, Secretary, 619 Central Building, Los Angeles, Cal.

Regular monthly meetings are held on the second Wednesday of each month, the Annual Meeting in December. Informal luncheons in connection with the Joint Technical Societies of Los Angeles are held at 12.15 P. M., every Thursday at the Broadway Department Store Café.

Louisiana Section (Constitution Approved by Board, 1914).

Ole K. Olsen, President; F. A. Muth, Secretary, 224 Custom House Building, New Orleans, La.

Regular meetings are held at The Cabildo, New Orleans, La., on the first Monday of January, April, July, and October.

Nashville Section (Constitution Approved by Board, 1921).

Arthur J. Dyer, President; Granbery Jackson, Secretary-Treasurer, 220 Capitol Boulevard, Nashville, Tenn.

Nebraska Section (Constitution Approved by Board, 1917).

William Grant, President; Homer V. Knouse, Secretary-Treasurer, 200 City Hall, Omaha, Nebr.

Regular meetings are held on the first Saturday of each month, except July and August. The Annual Meeting is held in Lincoln, Nebr., on the second Friday in January. Visiting members of the Society are especially urged to communicate with the Secretary when in the city.

New York Section (Constitution Approved by Board, 1920).

Nelson P. Lewis, President; J. P. J. Williams, Secretary, 33 West 39th Street, New York City.

Regular meetings are held in the Engineering Societies Building, 29 West 39th Street, New York City, on the third Wednesday of each month, except January and the Annual Meeting in May, held on the second Wednesday of the month.

Northeastern Section (Constitution Approved by Board, 1921).

Frank B. Sanborn, Chairman; Charles W. Banks, Secretary, Wentworth Institute, Boston, Mass.

Northwestern Section (Constitution Approved by Board, 1914).

Charles L. Pillsbury, President; Paul C. Gauger, Secretary, 945 Osceola Avenue, St. Paul, Minn.

Meetings are held bi-monthly, alternating between St. Paul and Minneapolis, on the third Friday of each month.

Oklahoma Section (Constitution Approved by Board, 1920).

Max L. Cunningham, President; R. E. Brownell, Secretary-Treasurer, 402 First National Bank Building, Oklahoma, Okla.

Philadelphia Section (Constitution Approved by Board, 1913).

Benjamin Franklin, President; S. C. Hollister, Secretary, 1200 Land Title Building, Philadelphia, Pa.

Regular meetings are held at the Engineers' Club on the first Monday in January, April, and October, the last being the Annual Meeting. Special meetings are also held at times announced in advance.

Pittsburgh Section (Constitution Approved by Board, 1918).

J. N. Chester, President; Nathan Schein, Secretary-Treasurer, 1510 Carson Street, Pittsburgh, Pa.

Portland (Ore.) Section (Constitution Approved by Board, 1913).

F. M. Randlett, President; C. P. Keyser, Secretary, 318 City Hall, Portland, Ore.

Meetings are held regularly on the third Friday of each month. All members of the Society in any grade are cordially invited to attend.

Providence (R. I.) Section (Constitution Approved by Board, 1920).

Sydney Wilmot, Chairman; Robert L. Bowen, Secretary-Treasurer, 26 Sycamore Street, Providence, R. I.

The Section regularly holds meetings jointly with the Structural and Municipal Sections of the Providence Engineering Society, at the Society Rooms, 29 Waterman Street, on the fourth Tuesday of each month, from September to May. The Annual Meeting is held in May. All visiting members of the Society are cordially invited to attend these meetings.

St. Louis Section (Constitution Approved by Board, 1914).

E. B. Fay, President; William C. E. Becker, Secretary-Treasurer, 426 City Hall, St. Louis, Mo.

The Annual Meeting is held on the fourth Monday in November. Two meetings each year for the presentation and discussion of technical papers are held in the Auditorium of the Engineers' Club, and are open to members of the Associated Societies. Other "get-together" meetings are held regularly for dinner or luncheon on the fourth Monday of each month except July, August, and November.

San Diego Section (Constitution Approved by Board, 1915).

F. J. Grumm, President; J. Y. Jewett, Secretary-Treasurer, Administration Building, Balboa Park, San Diego, Cal.

Regular meetings are held on the third Tuesday of each month at the Chamber of Commerce. Visiting members of the Society are invited to attend.

Seattle Section (Constitution Approved by Board, 1913).

F. F. Sinks, President; Frank H. Fowler, Secretary-Treasurer, 1319 L. C. Smith Building, Seattle, Wash.

Regular meetings, with luncheon, are held at the Engineers' Club, on the last Monday of each month. All members in any grade of the Society are cordially invited to attend, and if located in this District for any length of time, their membership in the Section will be appreciated.

Spokane Section (Constitution Approved by Board, 1914).

E. G. Taber, President; Charles E. Davis, Secretary-Treasurer, 401 City Hall, Spokane, Wash.

Meetings are held on the second Friday of each month. These meetings are noonday luncheons at Davenport's, and all visiting members of the Society are invited to attend.

Texas Section (Constitution Approved by Board, 1913).

E. B. Cushing, President; E. N. Noyes, Secretary, 1107 Dallas County Bank Building, Dallas, Tex.

Utah Section (Constitution Approved by Board, 1916).

W. R. Armstrong, President; H. S. Kleinschmidt, Secretary-Treasurer, 222 Felt Building, Salt Lake City, Utah.

The Annual Meeting is held on the first Wednesday in April. The time of other meetings is not fixed, but this information will be furnished on application to the Secretary.

STUDENT CHAPTERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS*

Stanford University Student Chapter, Organized 1920.

R. I. Hill, President; John H. Colton, Corresponding Secretary, Box 121, Stanford, Cal.

Alabama Polytechnic Institute Student Chapter, Organized 1921.

Alfred D. Boyd, Secretary, Alabama Polytechnic Institute, Auburn, Ala.

Braune Civil Engineering Society (University of Cincinnati) Student Chapter, Organized 1920.

John W. Guilday, President; C. A. Harrell, Secretary of Section 10; R. Blickensderfer, Secretary of Section 20; University of Cincinnati, Cincinnati, Ohio.

California Institute of Technology Student Chapter, Organized 1921.

W. M. Taggart, President; Douglas A. Stromsoe, Secretary, California Institute of Technology, Pasadena, Cal.

Carnegie Institute of Technology Student Chapter, Organized 1922.

J. K. Elliott, Secretary, Carnegie Institute of Technology, Pittsburgh, Pa.

Cornell University Student Chapter, Organized 1921.

T. D. Finn, Jr., President; James Hannigan, Secretary-Treasurer, Lincoln Hall, Cornell University, Ithaca, N. Y.

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* By a recent ruling of the Board of Direction, the minimum membership of a Student Chapter has been fixed at 12 instead of 20.

Drexel Institute Student Chapter, Organized 1920.

C. V. Nishwitz, Chairman; Raymond Radbill, Secretary, Drexel Institute, Philadelphia, Pa.

Iowa State College Student Chapter, Organized 1920.

Raymond L. Whammel, President; G. La Verne Day, Secretary, Iowa State College, Ames, Iowa.

Johns Hopkins University Student Chapter, Organized 1921.

Eric M. Arndt, President; Melvin E. Scheidt, Secretary, Box 566, Homewood, Baltimore, Md.

Lafayette College Student Chapter, Organized 1922.

James D. Groff, Jr., Acting Secretary, Lafayette College, Easton, Pa.

Massachusetts Institute of Technology Student Chapter, Organized 1921.

D. H. McCreery, President; T. S. Wray, Secretary, Massachusetts Institute of Technology, Cambridge, Mass.

Montana State College Student Chapter, Organized 1922.

Emmett Moore, Secretary, 921 South Third Avenue, Bozeman, Mont.

New York University Student Chapter, Organized 1921.

George H. Martin, President; Abram J. Jacobs, Secretary, 302 Gould Hall, New York University, New York City.

Ohio State University Student Chapter, Organized 1922.

O. W. Merrell, President, 65 Thirteenth Avenue, Columbus, Ohio.

Oregon State Agricultural College Student Chapter, Organized 1921.

Richard D. Slater, President; Wilbur H. Welch, Secretary, Oregon State Agricultural College, Corvallis, Ore.

Pennsylvania State College Student Chapter, Organized 1920.

Arthur H. McFadden, President; William W. Seltzer, Secretary, Pennsylvania State College, State College, Pa.

Polytechnic Institute of Brooklyn Student Chapter, Organized 1921.

W. C. Hanning, President; S. Lordi, Secretary, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Purdue University Student Chapter, Organized 1921.

R. O. Edwards, President; W. C. Mason, Secretary-Treasurer, Purdue University, West Lafayette, Ind.

Rensselaer Polytechnic Institute Student Chapter, Organized 1920.

William Minot Thomas, President; Earl D. Hopkins, Secretary, 147 Eighth Street, Troy, N. Y.

Rose Polytechnic Institute Student Chapter, Organized 1921.

Robert Cash, President; F. Ray Martin, Secretary-Treasurer, Rose Polytechnic Institute, Terre Haute, Ind.

Rutgers College Student Chapter, Organized 1921.

L. C. Kuhl, President; A. C. Ely, Secretary, 105 Winants Hall, Rutgers College, New Brunswick, N. J.

State University of Iowa Student Chapter, Organized 1921.

James Fred Phillips, President; Louis E. Bagg, Secretary, State University of Iowa, Iowa City, Iowa.

Swarthmore College Student Chapter, Organized 1921.

Frank Lemke, President; H. Chandlee Turner, Jr., Secretary, Swarthmore College, Swarthmore, Pa.

Syracuse University Student Chapter, Organized 1921.

Arthur V. Dollard, Secretary, College of Applied Science, Syracuse University, Syracuse, N. Y.

University of California Student Chapter, Organized 1921.

H. G. Gerdes, Secretary, Care, Prof. Charles Derleth, Jr., College of Civil Engineering, University of California, Berkeley, Cal.

University of Colorado Student Chapter, Organized 1920.

Herbert Altvater, President; Charles Bowden, Secretary, 1229 University Avenue, Boulder, Colo.

University of Illinois Student Chapter, Organized 1921.

A. L. R. Sanders, President; M. E. Jansson, Secretary, University of Illinois, Urbana, Ill.

University of Kansas Student Chapter, Organized 1921.

W. W. Hoagland, President; Waldo G. Bowman, Secretary, 1106 Ohio Street, Lawrence, Kans.

University of Kentucky Student Chapter, Organized 1921.

H. J. Beam, President; H. E. Glenn, Secretary-Treasurer, 348 Harrison Avenue, Lexington, Ky.

University of Maine Student Chapter, Organized 1921.

George H. Ferguson, Jr., Secretary, University of Maine, Orono, Me.

University of Minnesota Student Chapter, Organized 1921.

C. L. Swanson, President, 1716 Tyler Street, N. E., Minneapolis, Minn.

University of Missouri Student Chapter, Organized 1922.

J. D. Sandker, Secretary, 407 West Broadway, Columbia, Mo.

University of Nebraska Student Chapter, Organized 1921.

J. E. Applegate, President; W. H. Mengel, Secretary, University of Nebraska, Lincoln, Nebr.

University of North Carolina Student Chapter, Organized 1921.

H. G. Baity, President; L. I. Lassiter, Secretary, University of North Carolina, Chapel Hill, N. C.

University of Pennsylvania Student Chapter, Organized 1920.

Charles W. Foppert, President; Fred Welchy, Secretary, University of Pennsylvania, Philadelphia, Pa.

University of Pittsburgh Student Chapter, Organized 1921.

L. W. Fletcher, President; J. M. Daniels, Secretary, University of Pittsburgh, Pittsburgh, Pa.

University of Texas Student Chapter, Organized 1921.

Frank Cannon, President; Claude Riney, Secretary, 1908 Wichita Street, Austin, Tex.

University of Washington Student Chapter, Organized 1921.

B. W. Brown, President; G. E. Large, Secretary, 4518 Eleventh Avenue, N. E., Seattle, Wash.

University of Wisconsin Student Chapter, Organized 1921.

E. K. Loverud, President; L. H. Kessler, Secretary, 235 West Gilman Street, Madison, Wis.

Virginia Military Institute Student Chapter, Organized 1921.

Benjamin F. Parrott, President; R. G. Hunt, Secretary-Treasurer, Virginia Military Institute, Lexington, Va.

Virginia Polytechnic Institute Student Chapter, Organized 1922.

J. Byron Herring, Secretary, Virginia Polytechnic Institute, Blacksburg, Va.

Washington University Collimation Club Student Chapter, Organized 1920.

William D. Rolfe, President; Erwin Bloss, Secretary, Washington University, St. Louis, Mo.

West Virginia University Student Chapter, Organized 1921.

J. E. Wheeler, President; Milton Jarrell, Secretary, 113 Beverly Avenue, Morgantown, W. Va.

Yale University Student Chapter, Organized 1921.

W. S. Moore, President; T. T. McCrosky, Secretary, Sheffield Scientific School, Yale University, New Haven, Conn.

PRIVILEGES OF ENGINEERING SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Members of the American Society of Civil Engineers will be welcome in the Reading Rooms and at the meetings of many engineering societies in all parts of the world. A list of such societies will be found on pages 48, 49, and 50 of the Year Book of the Society for 1921.

ANNUAL REPORT OF THE BOARD OF DIRECTION FOR THE YEAR ENDING DECEMBER 31st, 1921.

In compliance with the Constitution, the Board of Direction presents its report for the year ending December 31st, 1921.

MEMBERSHIP

The changes in membership are shown in the following table:

	Jan. 1st, 1921.			Jan. 1st, 1922.			Losses.				Additions.		Totals.		
	Resident.	Non-Resident.	Total.	Resident.	Non-Resident.	Total.	Transfer.	Resignation.	Dropped.	Death.	Transfer.	Election.	Loss.	Gain.	Increase.
Honorary Members	.....	3	3	.....	5	5	0	0	0	3	*2	3	3	5	2
Members	780	3 464	4 244	821	3 645	4 466	2	39	13	56	†169	163	110	332	222
Associate Members	738	4 289	5 027	788	4 443	5 231	167	71	52	25	‡65	¶454	315	519	204
Affiliates	65	110	175	62	110	172	3	3	2	6	.....	11	14	11	§3
Juniors	86	362	448	88	370	458	64	13	25	..	.....	112	102	112	10
Fellows	5	5	10	4	6	10	....	....	...	..	.....	.....	....	....	...
Totals	1 674	8 233	9 907	1 763	8 579	10 342	236	126	92	90	236	743	544	979	435

* 2 Members.
† 167 Associate Members, 2 Affiliates.
‡ 1 Affiliate, 64 Juniors.
‖ 5 Reinstatements.
¶ 7 Reinstatements.
§ Decrease.

The net increase in membership for the year is 435. This is somewhat remarkable in view of adverse business conditions during the past twelve months.

The total number of applications received has been 1 054: 745 for admission and 309 for transfer.

The losses by death during the year number 90, and are as follows:

Honorary Members (3): *Sir* Douglas Fox, Alexander Mackenzie, Hiram Francis Mills.

Members (56): David Herbert Andrews, William Edgar Baker, Edward Chester Barnard, John Bealle Battle, George Pierrepont Bland, William Henry Booth, William Henry Brenton, James Simpson Browne, John Ryan Burke, Frederick William Cappelen, Eliot Channing Clarke, Thomas Curtis Clarke, William Brown Cogswell, Hartwell Prentice Farrar, Richard Henwood Gillespie, Samuel Merrill Gray, Peter Conover Hains, John Baillie Henderson, Howard Carleton Holmes, David Carlisle Humphreys, Aron Lancaster Hunt, *Sir* John Kennedy, Eugene Willett Van Court Lucas, Michael Lehane Lynch, Wisner Martin, Willard Atherton Nichols, Paul Maningham Norboe, James Owen, Maurice Stiles Parker, Edmund Taylor Perkins, Philo Sackett Perkins, Hiram Phillips, Charles Henry Prior, John Charles Quintus, Charles Ward Raymond, William Harper Robinson, Bernhard Martin Samuelson, Robert Carlos Sattley, Adolph Eugene Schneeweiss, James Cruickshank Scorgie,

William Henry Searles, James Alexander Seddon, George Steele Skilton, M. Everhart Smith, George Duncan Snyder, Harry Elstner Talbott, Samuel Everett Tinkham, Alfred Thomas Tomlinson, Warren Chamberlain Tudbury, John Findley Wallace, George Herbert Webb, Thomas Delano Whistler, William Glyde Wilkins, John Wilson, Sebastian Wimmer, Preston King Yates.

Associate Members (25): Anthony George Armstrong, James Gibbons Browne, Joseph Miller Burkett, Dudley Chipley, Fred Wallis Daggett, William James Davis, Thomas George Elbury, Samuel Alexander Forter, Franklin Lincoln Gibboney, Richard Tuggle Goodwyn, Jr., John Edward Grady, Edgar Miller Graham, Gisli Gudmundsson, Arthur John Hart, Henry Harvie, Julius James Knoch, Charles Raymond Larkin, Harry Milton Lynde, Michael Joseph McDonough, Frederic Cramer Mierow, Ralph Ewart Robson, Andrew Francis Ross, Hugo Julius Scheuermann, Eliot Nichols Smith, William Albert Yeo.

Affiliates (6): Charles Whiting Bradley, George Lord Burrows, James Richard Donald Mackenzie, Calvin Tomkins, Joseph Agur Wells, James Francis Wrenn.

LIBRARY

The Engineering Societies Library received during 1921, a total of 2 429 volumes (1 394 by gift, 368 by purchase), 1 112 pamphlets (1 066 by gift, 46 by purchase), and 193 maps and plans, making a total of 157 530 now in the permanent collection.

Expenditures for books, periodicals, supplies, and salaries were approximately $27 000. The total attendance was 26 840, about 12% greater than in 1920. In addition, about 8 000 non-visitors were assisted by mail or telephone. The average daily attendance was 88.

The task of recataloging the collection still occupies the chief attention of the Library Staff. During the year 20 096 volumes were recataloged and 103 809 cards prepared and added to the catalog. The catalog now contains specific references to more than 33 513 subjects.

The Service Bureau made 332 searches and copies of searches, and translated 111 articles, totaling 289 000 words. It prepared 23 272 photoprints for 2 342 persons. The receipts for this work were about $15 749.19.

Among the unusual acquisitions of the year were a collection of French medals commemorative of important engineering events, presented by the Chairman of the Library Board, Robert A. Cummings, M. Am. Soc. C. E.; and a collection of autograph manuscripts of Robert Fulton and Benjamin H. Latrobe.

The Endowment Committee has continued with the same membership. In July, the Carnegie Corporation appropriated $10 000 annually for two years, to assist in meeting the expense of recataloging the Library, and, in September, the National Electric Light Association contributed $1 000 for library maintenance. These generous contributions are valuable not only for the material assistance they afford, but also in indicating the value that other organizations place on the Library as an aid to engineers.

READING ROOM

The Reading Room of the Society had an attendance during the year of 5 051, which is an increase of about 23% over 1920, the daily average being 17.

A number of new technical and several non-technical magazines have been added to the periodicals received regularly. The collection of new books of particular interest to civil engineers has been enlarged by donations from members of the Society as well as by purchase.

The monthly list of recent engineering articles of interest which is prepared by the assistants in the Reading Room contained 3 305 classified references to 91 periodicals and covered 76 pages. The usefulness of this list has been enhanced by the translation of the foreign titles.

EMPLOYMENT SERVICE

The Society has co-operated in the management and shared in the expense of the Employment Service maintained by the Federated American Engineering Societies. This service, initiated by Engineering Council in 1918, has proved increasingly useful. The number of men registered and placed is indicated below:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Number of men registered	195	174	183	200	166	293	128	123	107	139	86	111	1 905
Total men placed..	91	107	95	94	150	96	103	93	148	124	120	144	1 365

COMMITTEES

There are in existence at the present time seven Special Committees to report on engineering subjects, as follows:

To Codify Present Practice on the Bearing Value of Soils for Foundations (Authorized December 3d, 1912).

Stresses in Railroad Track (Authorized November 12th, 1913).

Highway Engineering (Authorized October 14th, 1919).

To Consider and Recommend for Adoption a Specification for Bridge Design and Construction (Authorized August 9th, 1920).

Industrial Education (Authorized April 25th, 1921).

General Form of Contract Standard Clauses (Authorized June 6th, 1921).

On Research (Authorized October 10th, 1921).

AMENDMENTS TO THE CONSTITUTION

A Revised Constitution was adopted by the Society October 5th (effective November 5th), 1921. The principal features of the new Constitution are the relegation to By-Laws of details of administration, a reduction of the Board from thirty to twenty-five members, and a change in the method of nominating and electing officers.

PUBLICATIONS

Owing to the necessity for strict economy the method followed since 1896 of publishing all papers and discussions in *Proceedings* was abandoned in August, 1920. Papers and discussions were published as separate pamphlets, and forwarded only to those members who made special request for them. This

method effected a considerable saving and was probably the best that could have been followed in the emergency that confronted the Society. It was, however, only a temporary expedient, and better financial conditions enabled the Board to return to the former method beginning with *Proceedings* for August, 1921.

During the year, in addition to the usual ten numbers of *Proceedings*, separate pamphlets, and the Year Book, there have also been issued an Index to Vols. I–LXXXIII, (1867–1920), inclusive, of *Transactions*, and two volumes of *Transactions*, *viz.*, LXXXIII (1919–20) and LXXXIV (1921); these publications contained a total of 6 422 pages. The average number of pages published during the past five years was 4 263.

It is a matter of congratulation that the volume of *Transactions* for the current year was issued in November, and it is hoped that succeeding volumes may be published as promptly.

The stock of the various publications of the Society kept on hand for the convenience of members and others now amounts to 107 565 copies, the cost of which to the Society for paper and press work only has been $19 869.27. During the year lack of storage room occasioned the disposal of a number of volumes of *Transactions* at greatly reduced rates, to the benefit of members who had joined after the publication of these volumes.

Summary of Publications for 1921.

	Issues.	Average edition.	Total pages.	Plates.	Cuts.
Proceedings (monthly numbers)	8	10 680	1 834	6	141
Pamphlets (Papers, Discussions, Memoirs, Society Affairs)	65	330	453	1	91
Transactions, Vol. LXXXIII	1	10 000	2 479	39	560
Transactions, Vol. LXXXIV	1	10 500	993	1	219
Index to *Transactions*, Vol. I–LXXXIII	1	11 000	272	..	..
Year Book	1	11 000	391	1	..
Total	77	....	6 422	48	1 011

The cost of publications, as determined by the bills actually paid during the year, has been:

For Paper, Printing, etc., *Proceedings*	$24 395.86
For Paper, Printing, etc., of 32 650 Extra Copies of Papers, Discussions, Memoirs, Technical Lists	2 769.23
For Paper, Printing, etc., *Transactions*, Vol. LXXXIII (balance due)	11 164.39
For Paper, Printing, etc., *Transactions*, Vol. LXXXIV	7 117.84
For 8 050 Extra Copies of Separate Papers, *Transactions*, Vol. LXXXIII	715.44
For 8 950 Extra Copies of Separate Papers for *Transactions*, Vol. LXXXIV	907.27
Carried forward	$47 070.03

Brought forward	$47 070.03
For Binding*, Boxes, etc., *Transactions*, Vol. LXXXIII	9 627.48
For Binding*, Boxes, etc., *Transactions*, Vol. LXXXIV	1 878.87
For Plates and Cuts	2 034.72
For Paper, Printing, etc., Index to *Transactions*, Vols. I–LXXXIII.	3 071.79
For Binding*, Boxes, etc., Index to *Transactions*, Vol. I–LXXXIII.	1 415.58
For Year Book	7 044.90
For Copyright and Sundry Expenses	79.23
Total	$72 222.60
Deduct amount received from sale of publications	4 712.38
Net expenditure for publications for 1921	$67 510.22

MEETINGS

Twenty-three meetings were held during the year as follows: At the Annual Meeting, 2; at the Annual Convention, 2; and 19 other meetings all of which, except the Annual Convention, were held at the Society Headquarters in the Engineering Societies Building. At these meetings there were presented 7 formal papers, 3 of which were illustrated with lantern slides; 5 lectures and addresses, 3 of which were illustrated with lantern slides and 2 with lantern slides and motion pictures; and 4 discussions, 1 of which was illustrated with lantern slides. There were also published 10 papers and 2 Progress Reports of Special Committees which were not presented at any meeting of the Society. The number of members and others who took part in the preparation and discussion of these papers, lectures, addresses, discussions, and reports of Special Committees was 304.

The Annual Convention was held in Houston, Tex., from April 27th to 30th, 1921, inclusive.

The total attendance at the 19 meetings of the Society was about 3 334. The registered attendance at the Annual Meeting was 1 087, and at the Annual Convention 173.

The meetings of the Society durings the year were as follows:

January 5th, 1921, "Europe To-day—An Engineer's Impressions", by Edward J. Mehren, Affiliate, Am. Soc. C. E.

January 20th, 1921, "The Engineer, his Future and Relation to the Economic Life of America", by Francis H. Sisson, Vice-President, Guaranty Trust Company, New York City.

February 2d, 1921, "Construction of the World's Largest Hydro-Electric Units", by John Lyell Harper, M. Am. Soc. C. E.

March 2d, 1921, "Report of the New York–New Jersey Port and Harbor Development Commission", by Benjamin Franklin Cresson, Jr., M. Am. Soc. C. E.

April 6th, 1921, "The Battle of Meuse-Argonne", by Maj.-Gen. John A. Lejeune, Commandant, U. S. Marine Corps, Washington, D. C.

April 27th, 1921, "Engineering Activities of the Houston District", by E. E. Sands, M. Am. Soc. C. E.; and, "Municipal Engineering: Ad-

* Paper binding only.

dress at the Annual Convention at Houston, Tex., April 27th, 1921", by George S. Webster, President, Am. Soc. C. E.

May 4th, 1921, "Vertical Lift Bridges", by Ernest E. Howard, M. Am. Soc. C. E.

June 1st, 1921, "A Model Engineer Viewed as a Superior Mechanism", by S. Bent Russell, M. Am. Soc. C. E.

September 7th and 8th, 1921 (Three Sessions), "National Port Problems": A Discussion.

October 5th, 1921, "Rainfall and Run-Off Studies", by C. E. Grunsky, M. Am. Soc. C. E.; "The Flood of June, 1921, in the Arkansas River, at Pueblo, Colorado", by James Munn and J. L. Savage, Members, Am. Soc. C. E.; "The San Antonio Flood of September, 1921", by C. Terrell Bartlett, M. Am. Soc. C. E.

November 16th, 1921 (One Session), "Stream Pollution and Sewage Disposal": An Informal Discussion.

November 16th, 1921, "Odors and Their Travel Habits", by L. L. Tribus, M. Am. Soc. C. E.

November 17th, 1921 (One Session), A Symposium on "Water Supply and Water Purification".

December 7th and 8th, 1921 (Six Sessions), Discussion on the Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.

MEDALS AND PRIZES

For the year ending July, 1920, prizes were awarded as follows:

The Norman Medal to J. A. L. Waddell, M. Am. Soc. C. E., for his paper entitled "The Economics of Steel Arch Bridges".

The J. James R. Croes Medal to B. A. Smith, M. Am. Soc. C. E., for his paper entitled "Arched Dams".

The Thomas Fitch Rowland Prize to Charles Evan Fowler, M. Am. Soc. C. E., for his paper entitled "Revision of the Niagara Railway Arch Bridge".

The James Laurie Prize to Dabney H. Maury, M. Am. Soc. C. E., for his paper entitled "Water Supply for the Camps, Cantonments, and Other Projects Built by the Construction Division of the United States Army".

The Collingwood Prize for Juniors to Floyd A. Nagler, Jun. Am. Soc. C. S.,* for his paper entitled "Verification of the Bazin Weir Formula by Hydro-Chemical Gaugings".

LOCAL SECTIONS

There are at the present time 34 Local Sections, seven of which were organized during the year as follows:

Buffalo Section	Nashville Section
Central Ohio Section	Northeastern Section
Kansas Section	Oklahoma Section
Kansas City Section	

A complete list of the Local Sections, with their officers, is published in each copy of *Proceedings*.

* Now Assoc. M. Am. Soc. C. E.

STUDENT CHAPTERS

There are at the present time 39 Student Chapters, thirty-one of which were organized during the year as follows:

Alabama Polytechnic Institute Student Chapter
Bucknell University Student Chapter
California Institute of Technology Student Chapter
Cornell University Student Chapter
Johns Hopkins University Student Chapter
Massachusetts Institute of Technology Student Chapter
New York University Student Chapter
Oregon State Agricultural College Student Chapter
Polytechnic Institute of Brooklyn Student Chapter
Purdue University Student Chapter
Rose Polytechnic Institute Student Chapter
Rutgers College Student Chapter
State University of Iowa Student Chapter
Swarthmore College Student Chapter
Syracuse University Student Chapter
University of California Student Chapter
University of Colorado Student Chapter
University of Illinois Student Chapter
University of Kansas Student Chapter
University of Kentucky Student Chapter
University of Maine Student Chapter
University of Minnesota Student Chapter
University of Nebraska Student Chapter
University of North Carolina Student Chapter
University of Pittsburgh Student Chapter
University of Texas Student Chapter
University of Washington Student Chapter
University of Wisconsin Student Chapter
Virginia Military Institute Student Chapter
West Virginia University Student Chapter
Yale University Student Chapter

FINANCES

In spite of the National economic depression and the large amount of unemployment among engineers generally, the financial condition of the Society has continued to improve. This is due to the substantial gain in membership during 1921 and the increase in dues of non-resident members.

The Society publications have been brought up to date during the year including Volumes LXXXIII and LXXXIV of *Transactions,* and an Index, at great expense, but, in spite of these heavy expenditures, there remains a cash balance on hand January 1st, 1922, practically the same as for the preceding year.

The Reports of the Acting Secretary and the Treasurer are appended.

By order of the Board of Direction,

ELBERT M. CHANDLER, *Acting Secretary.*

REPORT OF THE ACTING SECRETARY FOR THE

To the Board of Direction of the

Gentlemen:—I have the honor to present a statement of Receipts and Disbursements for the fiscal year of the Society, ending December 31st, 1921. There is also appended a general Balance Sheet showing the condition of the affairs of the Society.

Respectfully submitted,

Elbert M. Chandler,
Acting Secretary.

Receipts.

Balance on Hand, January 1st, 1921		$41 653.95
Entrance Fees	$19 070.00	
Current Dues	139 157.81	
Past Dues	5 698.09	
Advance Dues	46 741.29	
Binding	10 072.33	
Certificates of Membership	863.91	
Badges	4 222.62	
Sale of Publications	4 712.38	
Interest on Deposits	1 090.02	
Interest on Investments	522.75	
Annual Meeting	1 492.25	
Compounding Dues	600.00	
Rent from 57th Street Property	22 703.32	
Engineering News-Record to Establish Arthur M. Wellington Prize Fund	2 000.00	
Miscellaneous	1 035.78	
		259 982.55
		$301 636.50

YEAR ENDING DECEMBER 31st, 1921.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

DISBURSEMENTS.

Salaries of Officers	$10 099.98	
Clerical Help	39 736.41	
Publications	72 222.60	
Postage	13 953.42	
General Printing	10 472.24	
Office Supplies	2 976.56	
Badges	4 334.42	
Certificates of Membership	599.31	
Binding:		
Index and *Transactions* Vol. LXXXIII–LXXXIV	17 805.96	
Reading Room	506.48	
United Engineering Society:		
Rent for 15th and 16th Floors	10 924.97	
Library	9 250.00	
Meetings and Miscellaneous	1 987.61	
Furniture	2 975.05	
Mileage:		
Directors	12 617.07	
Nominating Committee	1 831.20	
Work of Committees	11 418.21	
Am. Eng. Standards Committee	1 500.00	
Annual Meeting (Gross Cost)	4 263.59	
Annual Convention	1 329.40	
Prizes	346.70	
Interest on Mortgage	10 000.00	
Current Business	3 601.71	
Retirement Allowances	7 666.67	
Employment Bureau	3 000.00	
Investment	2 036.46	
Reimbursement to J. Parke Channing	2 750.00	
Miscellaneous	524.25	
		$260 730.27
Balance on Hand, December 31st, 1921:		
In Garfield National Bank	$39 406.23	
Cash on Hand	1 500.00	
		40 906.23
		$301 636.50

GENERAL BALANCE SHEE

Accompanying Report (

Assets

Real Estate :			
One-fourth interest in U. E. S. real estate, 25 to 33 West 39th Street		$489 785.17	
Three lots (actual cost $185 406.20), estimated value		350 000.00	
Building, 220 West 57th Street, with improvements, at cost	$242 029.99		
Less reserve for depreciation	49 329.21	192 700.78	$1 032 485.95
Equipment :			
Furniture and office equipment	$40 657.11		
Less reserve for depreciation	10 848.48	$29 808.63	
Library :			
Cash expended for books, etc	$22 122.22		
Donations (estimated)	72 310.83	94 433.05	124 241.68
Investments :			
$10 000 New York City non-taxable 4¼% bonds		$10 000.00	
$2 300 U. S. Liberty Loan, Fourth, 4¼% bonds, at cost		1 996.00	11 996.00
Working assets :			
Publications on hand (inventoried cost)		$19 869.27	
Unexpired insurance premiums		192.64	20 061.91
Current assets :			
Cash, including $1 500 in hands of Secretary		$40 906.23	
Alfred Noble Memorial (loan)		1 200.00	
Members' accounts (past due)		20 207.23	
Miscellaneous accounts receivable		1 336.90	
Interest accrued on investments		161.15	63 811.51
			$1 252 597.05

We have audited the accounts of the American Society of Ci estimate of the property valuation is correct), we certify that, in our opini Society at that date.

New York, January 13th, 1922.

CEMBER 31ST, 1921.

E ACTING SECRETARY.

LIABILITIES

Dues for 1922 paid in advance		$46 741.29
Interest accrued on mortgage		4 166.70
Balance of donations on account of work of Special Committees..		1 615.25
Mortgage payable, due January 27th, 1924		200 000.00
Funds :		
Fund invested in Society House, Lots and Library*	$31 415.78	
Herbert Steward Library Fund	2 000.00	
Joseph G. Swift " "	1 000.00	
Arthur M. Wellington Prize Fund	2 000.00	36 415.78
Surplus (including Reserve Fund of $7 000)		963 658.03
		$1 252 597.05

* Compounding Dues Fund, $15 155; Norman Medal Fund, $1 000 ; Rowland Prize Fund, $1 222.50 ; Collingwood Prize Fund, $1 000 ; Fellowship Fund, $13 038.28.

INEERS for the year ended December 31st, 1921, and (assuming that the above balance sheet sets forth correctly the financial condition of the

LYBRAND ROSS BROS. & MONTGOMERY,

Accountants and Auditors.

REPORT OF THE TREASURER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS FOR THE YEAR ENDING DECEMBER 31st, 1921.

In compliance with the provisions of the Constitution, I have the honor to present the following report:

Cash on Hand, January 1st, 1921			$41 653.95
Receipts.			
From current sources, January 1st to December 31st, 1921		$235 279.23	
Rent from 57th Street Property, January 1st to December 31st, 1921		22 703.32	
From *Engineering News-Record* to establish Arthur M. Wellington Prize Fund		2 000.00	$259 982.55
Expenditures.			
Payment of bills by audited vouchers for current business, January 1st to December 31st, 1921		$255 943.81	
Reimbursement to J. Parke Channing		2 750.00	
Purchase of $2 300—4¼% Liberty Loan			
Bonds	$1 996.00		
Accrued interest	40.46	2 036.46	
Balance on Hand, December 31st, 1921:			
In Garfield National Bank	$39 406.23		
Cash on hand	1 500.00	40 906.23	
		$301 636.50	$301 636.50

Respectfully submitted,

Otis E. Hovey,

Treasurer.

NEW BOOKS*

(From January 2d to January 31st, 1922)

The statements made in these notices are taken from the books themselves, and this Society is not responsible for them.

DONATIONS TO ENGINEERING SOCIETIES LIBRARY

PROTECTIVE RELAYS.

By Victor H. Todd. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 274 pp., illus., diagrams, 8 x 6 in., cloth. $2.50.

This book attempts to cover the subject from first principles to the protection of high-tension networks, in a manner suited to the needs of operators and testers with a fair knowledge of electricity, and also of designers.

THEORY OF THE INDUCTION COIL.

By E. Taylor-Jones. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 217 pp., illus., 8 x 5 in., cloth. $3.50.

Until recently there has been much divergence of view as to the manner in which the high potential is generated at the secondary terminals of an induction coil when the primary current is interrupted, and it cannot be said even now that opinion on the subject is quite undivided. In this book an account is given of a theory of the action of induction coils first put forward by the author in 1909. The theory was originally intended to apply only to the case of an air-core induction coil having a condenser connected with its secondary terminals. Subsequent investigations have shown that it is also applicable to an ordinary induction coil.

SHORT COURSE IN THE TESTING OF ELECTRICAL MACHINERY.

By J. H. Morecroft and F. W. Hehre. Fourth Edition, Revised and Enlarged. N. Y., D. Van Nostrand Co., 1921. 220 pp., diagrams, 9 x 6 in., cloth. $3.00.

All students of engineering at Columbia University are required to take courses in testing direct and alternating-current machinery. These notes are prepared to meet the needs of students in mining, mechanical, and civil engineering, who have not studied the theory of electrical machinery, and hence need a brief summary of it as preparation for the laboratory work. Besides giving specific directions for the tests, a brief analysis of the characteristics of the machines is given. The new edition includes new material on batteries, illumination, measurement of electrical energy, and other subjects of interest to engineers generally.

HANDBUCH DER DRAHTLOSEN TELEGRAPHIE UND TELEPHONIE.

By Eugen Nesper. Berlin, Julius Springer, 1921. 2 vol., illus., diagrams, 10 x 7 in., cloth.

Dr. Nesper's book on radio communication attempts an exhaustive survey of the subject from a modern point of view and from every aspect. It is apparently more extensive than any previous work on the subject. It has been planned for easy reference, the material having been arranged so that each chapter is a complete account of a certain topic, so that reference to other chapters, or systematic reading of the whole work, can be avoided. The theory of radio communication, its history, uses, the measuring and detecting instruments, the physical phenomena in quasi-stationary circuits, coupling, damping, radiating, the technique and apparatus of high-frequency measurements are described in Vol. 1. Vol. 2 describes typical radio stations for different purposes, and their apparatus, the uses of radio communication in railroading, and radio telephony. It also includes a valuable bibliography of the important books and articles on the subject. Good indexes are provided.

EDGE MOOR WATER TUBE BOILER.

Edge Moor, Del., Edge Moor Iron Co., 1922. 153 pp., illus., 9 x 6 in., cloth.

In addition to technical information concerning the Edge Moor boiler and its merits, this volume contains data on oil firing, waste heat recovery, the properties of fuels, water purification, steam tables, etc.

AIRPLANE ENGINE.

By Lionel S. Marks. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 454 pp., diagrams, tab., 9 x 6 in., cloth. $6.00.

This volume attempts to formulate existing knowledge of the functioning of the airplane engine and its auxiliaries, and to present and discuss the essential constructive details of those engines, the excellence of which has resulted in their survival. Most of the material

* Unless otherwise specified, books in this list have been donated by the publishers.

is new, being based on the researches and developments that originated during the World War. Professor Marks has summarized and arranged the detailed data on the engine designs used in various countries, so that they are in convenient form for the designer.

HISTORY OF AERONAUTICS.

By E. Charles Vivian. N. Y., Harcourt, Brace and Co., 1921. 521 pp., pl., ports., 9 x 6 in., cloth. $5.00.

The author of this work says that hitherto there has been no attempt to furnish a detailed account of how the æroplane and the dirigible of to-day came into being, but each author has devoted his attention to some special phase or period. In this book, he attempts to record the facts of development and to state, as fully as is possible within the compass of a single volume, how flight and ærostation have evolved. Contents: The Evolution of the Aeroplane; 1903–1920; Progress in Design; Aerostatics; Engine Development.

MASCHINENUNTERSUCHUNGEN UND DAS VERHALTEN DER MASCHINEN IM BETRIEBE.

By A. Gramberg. Zweite, Erweitete Auflage. (Maschinentechnisches Versuchswesen, Bd. 2.) Berlin, J. Springer, 1921. 681 pp., illus., 9 x 6 in., cloth.

This book comprises Vol. 2 of the author's treatise on methods for testing machines, the first volume of which is devoted to measuring apparatus. This volume discusses methods of testing and the behavoir of machines while running. The subjects treated include boiler tests, fuel tests, heat conductivity, steam turbines, and reciprocating engines, exhaust steam utilization, internal combustion engines, pumping machinery, blowers, air compressors, and refrigerating machines. A section is devoted to regulation and governing, and an introductory section discusses the economic and legal aspects of tests. The work is intended to assist in the selection of proper tests, to describe correct tests, and to indicate how the results of costly tests can be fully analyzed.

METALLURGY OF ZINC AND CADMIUM.

By H. O. Hofman. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 341 pp., diagrams, tab., 9 x 6 in., cloth. $4.00.

This volume resembles the author's previous treatises on copper and lead in its general characteristics and, like them, is supplied with copious references to the literature. The work is designed to include recent advances in the metallurgy of zinc and cadmium, and to discuss these from a chemical as well as a technical point of view.

MANUAL OF FLOTATION PROCESSES.

By Arthur F. Taggart. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 181 pp., diagrams, 9 x 6 in., cloth. $3.00.

Widespread understanding of the physical principles underlying flotation phenomena and of the diversity of flotation processes has been delayed, partly by the apparent complexity of the phenomena and the difficulties of investigation, and partly by the attitude of corporations owning patents on flotation processes. It is the purpose of this book, in part, to counteract the further spread of false conceptions, by setting forth some of the facts that contradict them, in part to describe apparatus and methods of testing which will aid investigators in their researches; and, finally, to give some generalizations from mill practice, by means of which the investigator may translate laboratory results into commercial operations.

ELEMENTS OF FRACTIONAL DISTILLATION.

By Clark Shove Robinson. (International Chemical Series.) N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 205 pp., diagrams, tab., 8 x 6 in., cloth. $2.50.

This book explains the principles of fractional distillation and illustrates them by carefully selected examples of their application. The first portion of the book treats of fractional distillation from the qualitative viewpoint of the phase rule; the second discusses some quantitative aspects from the engineering point of view; and the third section treats of the design of distilling apparatus. Part four gives examples of modern apparatus for distilling ammonia, benzolized wash oils, and alcohols. An Appendix of useful tables is included.

ATOMIC THEORIES.

By F. H. Loring. N. Y., E. P. Dutton and Co., 1921. 218 pp., illus., 9 x 6 in., cloth. $5.00.

The leading facts and theories relating to the atom, particularly those which, owing to their newness, have not yet been treated at any length in textbooks, are brought together in one volume for the convenience of students and investigators. The book covers a wide range of subjects. These include the quantum theory, *Sir* J. J. Thomson's recent views of mass, matter, and radiation, the Bohr theory, the octet theory, isotopes, the Brownian movement, ionisation, potentials, solar phenomena, and other subjects. References are given throughout, which enable the reader to follow any subject of special interest.

LA MATIÈRE ET L'ÉNERGIE SELON LA THÉORIE DE LA RELATIVITÉ

Et La Théorie des Quanta. By Louis Rougier. Nouvelle Edition, Revue et Augmentée. Paris, Gauthier-Villars et Cie., 1921. 112 pp., 10 x 7 in., paper. 9.50 francs.

This book calls attention to the most paradoxical and least discussed consequence of the principle of relativity, that which attributes mass, weight, and structure to energy. What we call matter thus becomes only a particular case of energy. The old duality of ponderable and imponderable makes way for that of the electro-magnetic field or energy, of which radiation and matter are simple modalities, and of the field of gravitation or space as defined by Einstein. Professor Rougier presents these theories in this work.

PHYSIQUE ÉLÉMENTAIRE ET THÉORIES MODERNES.

By J. Villey. Part 1: Molécules et Atomes. Paris, Gauthier-Villars et Cie., 1921. 197 pp., 10 x 6 in., paper. 15 francs.

The author has prepared a work, less scholastic than usual textbooks and more suited for reading, in which the essential phenomena of physics are set forth and explained by the most modern theories. Attention is especially directed to those phenomena which have received industrial application. The work is intended for the general public desirous of information about the fundamentals of physics and modern theories, as well as for use as a textbook.

INDUSTRIAL FATIGUE AND EFFICIENCY.

By H. M. Vernon. Lond., George Routledge & Sons, Ltd.; N. Y., E. P. Dutton & Co., 1921. 264 pp., tab., 9 x 6 in., cloth. $5.00.

The author, who is an investigator for the Industrial Fatigue Research Board of Great Britain, presents a fairly complete account of present knowledge concerning industrial fatigue and its influence on efficiency. The information adduced relates only to shop practice, as laboratory investigations have not, in the author's opinion, afforded much evidence of practical value.

SYSTEM BUILDING AND CONSTRUCTIVE ACCOUNTING.

By Raymond D. Willard. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 307 pp., forms, 9 x 6 in., cloth. $4.00.

A textbook for students of accounting, devoted to the design of systems for various lines of business. The book analyzes a number of systems in use, thus illustrating the principles involved, and illustrates by charts and forms, suitable methods for the necessary records.

ESSENTIALS OF INDUSTRIAL COSTING.

By George S. Armstrong. N. Y., D. Appleton and Co., 1921. 297 pp., tab., forms, 9 x 6 in., cloth. $5.00.

As indicated by the Contents, this book is concerned solely with the principles and methods by which the cost of production may be determined. It is based on an extended experience in many different industries and represents the author's mature views. The book shows the purpose of costing, summarizes good practice, and is a guide to the analysis necessary for the establishment of costing systems. Contents: Economic Development and Necessity of Costing; The Purpose and Function of Costing; The Mechanism of Costing; Elements of Costing and Sources of Costing Data; The Costing of Material; The Costing of Labor; The Collection of Expense in Costing; The Costing of Depreciation, Interest, and Power; The Distribution and Application of Expense in Costing; Final Costing; The Connection of Costing with the General Books and the Preparation of Monthly Statements Therefrom.

DESCRIPTIVE GEOMETRY.

By George Young and H. E. Baxter. N. Y., The Macmillan Co., 1921. 310 pp., diagrams, 8 x 5 in., cloth. $3.25.

Believing that the chief value of descriptive geometry lies in its imaginative quality, these authors present it so as to develop the imagination; and, therefore, they encourage intuitive rather than rigidly formal methods. The treatment has been kept purely abstract, in order to avoid the tendency of the subject to degenerate into practical rules and formulas; but introductory matter showing the relation of the principles under discussion to structural work is provided, and exercises to show the application of the abstract ideas to concrete, practical problems are included.

VALUATION OF AMERICAN TIMBERLANDS.

By K. W. Woodward. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 246 pp., maps, 9 x 6 in., cloth. $3.00.

Gives the principal facts regarding the timber resources of the Continental United States and its outlying territories, excepting Hawaii and the Canal Zone, in a form suited to the needs of investors, timber cruisers, and students of forestry. Contains descriptions of the forest types of the country, and comparisons of their values.

MOTOR TRUCK TRANSPORTATION.

By F. Van Z. Lane. N. Y., D. Van Nostrand Co., 1921. 153 pp., illus., 9 x 6 in., cloth. $2.00.

A practical presentation of the principles of truck operating cost; operating efficiency, and cost records; operating cost laws; truck details, such as bodies, loading, and unloading devices, trailers and semi-trailers, and tires; and the factors that determine the fields of economical operation. Gives no attention to design or manufacture.

COTTON FACTS.

Compiled and Edited by Alfred B. Shepperson. Revised and Enlarged by C. W. Shepperson. N. Y., Shepperson Publishing Co., 1921. 180 pp., port., map, 7 x 4 in., cloth.

A convenient compilation of commercial and financial information required by those engaged in the cotton industry, which has appeared annually for forty-six years.

SEWERAGE AND SEWAGE DISPOSAL.

By Leonard Metcalf and H. P. Eddy. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 598 pp. illus., diagrams, 9 x 6 in., cloth. $5.00.

This work is practically a one-volume abridgment of the three-volume treatise "American Sewerage Practice", published by these authors in 1914–1915. It is intended for class use in engineering schools, but reflects the viewpoint of the engineer, not the teacher, and presents the information that its authors believe young students should acquire before taking up work in the field of sewerage engineering.

CONSTRUCTION, COST KEEPING AND MANAGEMENT.

By Halbert Powers Gillette and Richard T. Dana. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 572 pp., forms, 8 x 5 in., cloth. $5.00.

This book has been prepared in response to requests for a second edition of "Cost Keeping and Management Engineering". It contains nearly all the original material, supplemented by that developed in the last twelve years. It is intended to assist in reducing construction costs to the minimum, by explaining the rules of management and setting forth suitable methods of cost keeping, adapted to engineering construction.

DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES

In Framed Structures. By Milo S. Ketchum. Fourth Edition, Rewritten. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1921. 632 pp., illus., diagrams, 9 x 6 in., fabrikoid. $6.00.

The subject-matter of this book covers the calculation of the stresses in framed structures and also the design of buildings having a self-supporting steel frame with a light covering, usually fireproof. In this edition, the book has been rewritten, enlarged, and reset. It is intended as a textbook in structural engineering and also as a book of reference for engineers. Part 1 covers the calculation of the stresses in simple beams, trusses, portals, the transverse bent, and the three-hinged arch. Part 2 covers the calculation of the deflections of structures, the stresses in statically indeterminate girders, trusses and frames, and secondary stresses in trusses. Part 3, covers the design of steel frame buildings for mines, mills, smelters, and other industrial plants. The Appendix is a complete specification for steel frame mill buildings.

ARCHITECTS' AND BUILDERS' HANDBOOK.

By Frank E. Kidder. Seventeenth Edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 1907 pp., illus., tab., 7 x 4 in., fabrikoid. $7.00.

Two new chapters, on "Specifications for the Steelwork of Buildings", and on "Domical and Vaulted Structures", have been prepared for this edition. The chapters on "Fireproofing of Buildings" and on "Reinforced-Concrete Construction" and the sections on "Heating and Ventilation" and on "Chimney Construction" have been rewritten. In addition, the whole text has been revised, numerous new articles inserted, and a new index made. The total additions amount to 90 pages. The book is intended to contain information on every subject, except design, likely to come before an architect, structural engineer, draftsman, or builder, and to be a thorough handbook of architectural engineering.

DIE EISENKONSTRUKTIONEN.

By L. Geusen. Dritte, Verbesserte Auflage. Berlin, Julius Springer, 1921. 282 pp., diagrams, tab., 11 x 8 in., cloth. 384 marks.

This textbook for students of structural engineering is divided into three sections, treating, respectively, of the principles of steel buildings and of bridges. By this arrangement the general rules and methods governing steel structures are taught first and emphasized by suitable problems taken from practice. The application of these methods in framing buildings and bridges is considered in the later sections. The text is concise and illustrated by numerous drawings. An appendix contains the necessary tables of the properties of structural shapes.

HYDRAULICS AND ITS APPLICATIONS.

By A. H. Gibson. New Edition, Revised and Enlarged. N. Y., D. Van Nostrand Co., 1921. 813 pp., illus., diagrams, 9 x 6 in. cloth. $6.00.

This book opens with a description of the physical properties of water, followed by a brief treatment of the fundamentals of hydrostatics. The science of hydraulics is then presented, first theoretically, and then with regard to its application to the design of hydraulic machinery. The work is written primarily for students, but the author hopes it may also prove of value to those actively engaged in the practice of hydraulic engineering. This edition has been practically rewritten, with considerable additions and much re-arrangement of the material.

DIE WASSERVERSORGUNG DER STÄDTE.

By O. Smreker. Fünfte Auflage. (Handbuch der Ingenieurwissenschaften. Teil 3, Der Wasserbau, Bd. 3.) Leipzig, Wilhelm Engelmann, 1914. 522 pp., illus., diagrams, tab., 10 x 7 in., cloth. 57 marks.

This work forms the third of the twelve volumes upon Hydraulic Engineering which constitute the third section of the "Handbuch der Ingenieurwissenschaften", and is concerned with municipal water supplies. The present edition has been thoroughly revised, both with respect to arrangement and contents. The arrangement follows the course of operations used in securing a water supply, discussing first the preliminary studies of the amount, quality, and occurrence of the available sources, then the design of the plant in general. Succeeding chapters discuss the winning and purification of water, pumping, and conveying, and the operation of water-works. Attention is directed toward general principles, rather than to the details of specific installations.

DONATIONS TO THE READING ROOM

TRAIN OPERATION BY SIGNAL INDICATION.

By Henry M. Sperry, M. Am. Soc. C. E. N. Y., 1919–20. 3 pamphlets, illus., 11 x 8½ in., pap. (Gift of the Author.)

These pamphlets bring together scattered facts and arguments concerning train despatching and signaling. The author proposes to abandon all written orders and to extend the practice of conveying instructions to enginemen entirely by means of signal arms supported on roadside posts. The Contents are: Bulletin No. 1, Train Operation by Signal Indication; Susquehanna Division, Erie Railroad; Bulletin No. 2, Pt. 1, What Time Saved by Signals Means in Equipment; Pt. 2, What Does It Cost to Stop a Tonnage Train?; Bulletin No. 3, Pt. 1, The Two Principal Methods of Directing Train Movements; Pt. 2, Directing Train Movement by Signal Indication.

MEMBERSHIP

(From January 4th to January 31st, 1922)

ADDITIONS

HONORARY MEMBERS

		Date of Membership.
LUIGGI, LUIGI. Insp. Gen. of Civ. Engrs.; Prof. of Hydr. Eng., Univ. of Rome; Member of the International Technical Committee for the Suez Canal, 68-B Via Nomentura, Rome, Italy....	M. Hon. M.	Feb. 7, 1906 Oct. 10, 1921

MEMBERS

BLOECHER, THEODORE, JR., Div. Engr., B. & O. R. R., 4005 Garrison Boulevard, Baltimore, Md....................	M.	Jan. 16, 1922
BURNEY, ROBERT LEE. Gen. Contr. (Walsh & Burney), 303 Calcasieu Bldg., San Antonio, Tex........	Assoc. M. M.	April 7, 1915 Jan. 20, 1922
BYRNES, HARRY CADY. Div. Engr., State Highway Dept., Room 128, Court House, Pueblo, Colo....	Assoc. M. M.	Oct. 11, 1920 Jan. 20, 1922
CAUGHEY, ROBERT ANDREW. Associate Prof. of Structural Eng., Iowa State Coll., 224 Stanton Ave., Ames, Iowa	Assoc. M. M.	April 14, 1919 Jan. 20, 1922
CONNER, PERLEY EUGENE. Contr. Engr., Chicago Office, States Contr. Co., 122 South Michigan Ave., Chicago, Ill.	Assoc. M. M.	April 14, 1919 Jan. 20, 1922
COULTER, WALDO SCARLETTE. Cons. Engr., 114 Liberty St., New York City (Res., 90 Fenimore St., Brooklyn, N. Y.).........................	Assoc. M. M.	May 6, 1908 Jan. 20, 1922
GANDOLFO, JOSEPH HARRINGTON. Constr. Mgr., Div. of Architecture and Constr., Dept. of Institutions and Agencies, State of New Jersey, 142 West State St., Trenton, N. J...............	Assoc. M. M.	Oct. 2, 1907 Jan. 20, 1922
HARWI, SOLOMON JACOB. 910 Ave. C, Bayonne, N. J.	Jun. M.	Dec. 4, 1889 Jan. 16, 1922
HOPKINS, JOHN THOMAS. Chf. Engr. and Mgr., Hopkins Constr. Corporation, 40 Paterson St., New Brunswick, N. J.........................	Assoc. M. M.	June 16, 1919 Jan. 20, 1922
JONES, JOSEPH WARREN. Mgr., Austin Bros., Box 1328, Dallas, Tex.........................	Assoc. M. M.	Jan. 2, 1912 Jan. 20, 1922
KELLY, WILLIAM. Col., Corps. of Engrs., U. S. A.; Chf. Engr., Federal Power Comm., Interior Bldg., Washington, D. C...........................	Assoc. M. M.	Feb. 3, 1904 Jan. 20, 1922
KENNISON, KARL RAYMOND. Cons. Engr., 25 Pemberton Sq., Boston, Mass...	Assoc. M. M.	Jan. 6, 1915 Jan. 20, 1922
KENT, HERBERT VAUGHAN. Cons. Engr., 17 Hanover Sq., London, W. 1, England....................................		Jan. 19, 1920
MALSBURY, OMER EVERT. Asst. Engr., Head of Section of Surveys, Panama Canal, Balboa Heights, Canal Zone, Panama......................	Jun. Assoc. M. M.	Feb. 5, 1907 Feb. 4, 1914 Nov. 21, 1921
MARCELLUS, JONTA BOEN. Associate Prof., Civ. Eng., Univ. of Colorado, Coll. of Eng., Boulder, Colo....................		Sept. 12, 1921
MORRISON, ROGER LEROY. Secy., Treas., and Gen. Mgr., The Concrete Products Co., 4717 First Ave., Birmingham, Ala.	Jun. Assoc. Assoc. M. M.	April 4, 1911 Mar. 2, 1915 Sept. 11, 1917 Jan. 20, 1922

MEMBERS—(*Continued*)

		Date of Membership.
NICHOLS, CHARLES SABIN. Prof., San. and Hydr. Eng., Iowa State Coll., 830 Hodge Ave., Ames, Iowa	Assoc. M. M.	June 18, 1918 June 6, 1921
NOYES, STEPHEN HENLEY. Asst. Engr., in Chg. of Bridge Div., Bureau of Surveys, Dept. of Public Works, City Hall, Philadelphia, Pa	Jun. Assoc. M. M.	Oct. 1, 1907 Feb. 6, 1912 Jan. 20, 1922
RATHBUN, JOHN CHARLES. Asst. Prof., Civ. Eng., Univ. of Washington, 4034 University Way, Seattle, Wash.	Jun. Assoc. M. M.	Oct. 6, 1908 May 6, 1914 Sept. 12, 1921
SMITH, ALVA J. City Engr. and Water Supt., 619 East 6th Ave., Emporia, Kans.		Jan. 16, 1922
SPELMAN, JOHN RODGERS. Cons. and Superv. Engr., 405 Lexington Ave., New York City (Res., 219 Lakeview Ave., Rockville Centre, N. Y.)	Assoc. M. M.	Dec. 6, 1910 Jan. 20, 1922
THOMPSON, GUSTAVUS WILLIAM. Pres., Thompson & Binger, Inc., 317 Gurney Bldg., Syracuse, N. Y.	Assoc. M. M.	July 9, 1912 Jan. 20, 1922
WARNER, ELWIN STREETER. Highway Engr., Bureau of Public Roads, Dist. No. 6, Care, State Highway Dept., Austin, Tex	Assoc. M. M.	Oct. 1, 1913 Nov. 21, 1921

ASSOCIATE MEMBERS

ANDERSON, BJARNE BERGSLAND. Care, Am. Bridge Co., 30 Church St., New York City	Jun. Assoc. M.	Oct. 14, 1919 Jan. 16, 1922
ANDERSON, JOHN DAVID. Engr., Dwight P. Robinson & Co., Inc., 125 East 46th St., New York City (Res., 1075 Prospect Pl., Brooklyn, N. Y.)		Jan. 16, 1922
BRALY, RAYMOND FIELDING. Vice-Pres., Concrete Products Co. of New Jersey, Box 248, Spring Lake, N. J.	Jun. Assoc. M.	Nov. 28, 1916 Jan. 16, 1922
CHILDS, JAMES HENDERSON. 532 Eldorado St., Pasadena, Cal.		Nov. 21, 1921
DOUGLAS, FREDERICK WILLIAM. With The Foundation Co., 525 West 124th St., New York City		Jan. 16, 1922
FISHER, ROBERT RAYMOND. Engr., The Trewhitt-Shields Co., 435 Rowell Bldg., Fresno, Cal		Jan. 16, 1922
HAMILTON, ANDREW CLAUDE, JR. Cons. Engr. (Hamilton & Shreve), Fayetteville, Ark.		June 6, 1921
LEWIS, FRED JUSTIN. Asst. Prof., Civ. Eng., Lehigh Univ., 1239 Russell Ave., South Bethlehem, Pa		Nov. 21, 1921
MCMULLEN, ERNEST WILLIAM. Executive Engr., Monks & Johnson, Boston (Res., 60 Parkton Rd., Jamaica Plain), Mass		July 11, 1921
MOHR, WILLIAM HENRY. Plant Mgr., Lehigh Structural Steel Co., 10 North 13th St., Allentown, Pa		Nov. 21, 1922
OLIVER, GEORGE EDWIN. Drainage Engr., Monona County, Onawa, Iowa.		Jan. 16, 1922
PAGENHART, EDWIN HERBERT. Hydrographic and Geodetic Engr., U. S. Coast and Geodetic Survey, Box 2512, San Francisco, Cal.		Nov. 21, 1921
ROLLINS, JOSEPH GUY. Res. County Engr., Stephens County, Box 8, Breckenridge, Tex		Jan. 16, 1922
RUSSELL, WALTER CLAIR. Asst. Engr. in Chg. of Sewers, Eng. Dept., City of Flint, 833 East Eighth St., Flint, Mich		Jan. 16, 1922

ASSOCIATE MEMBERS—(*Continued*) — Date of Membership.

SCHLICH, OTTO STEPHEN. Asst. Engr., White Constr. Co., 95 Madison Ave., 16th Floor, New York City.................... Jan. 16, 1922

SMITH, GORDON PITMAN. Cons. Engr., 502 Central Bank Bldg., St. Paul, Minn.. Nov. 21, 1921

SPENCER, EARL MILTON. Chf. Engr. and Gen. Mgr., F. M. Spencer & Son, 10th and Van Buren Sts. (Res., 1165 College Ave.), Topeka, Kans. .... Jan. 16, 1922

SWEENEY, JOHN JOSEPH. Prof. of Civ. Eng., Villanova Coll., Villanova (Res., 5627 Kingsessing Ave., Philadelphia), Pa..... Jan. 16, 1922

TRIERWEILER, FRANK FREDERICK. Engr. and Contr. (Monson-Trierweiler Co., Inc.), 419 Railway Exchange Bldg., Portland, Ore. Jan. 16, 1922

WASHBURN, FRITZ LEROY. Asst. Cons. Engr., City of Decatur, Dept. of Streets and Public Impvts., 1133 North Edward St., Decatur, Ill. .... Jan. 16, 1922

WEITZNER, HENRY MITCHELL. 145 West 45th St., New York City .... { Jun. May 28, 1912; Assoc. M. Jan. 16, 1922 }

WYLIE, PAUL EUGENE. 3712 Eighth St., Des Moines, Iowa....... Jan. 16, 1922

JUNIORS

GARRISON, SYDNEY WOOD. Draftsman and Instrumentman, State Highway Comm., Raleigh, N. C.......................... Nov. 21, 1921

GORNTO, EARL DOUGLAS. Asst. Engr., M. of W., Virginia Ry. & Power Co., 1109 Huntington Crescent, Norfolk, Va......... Nov. 21, 1921

GREENE, BARCLAY ADAMS. Mgr., Cement Gun Dept., Pratt-Thompson Constr. Co., 500 Republic Bldg., Kansas City, Mo...... Nov. 21, 1921

LEWIS, ELBERT FRANCIS. Junior Hydrographic and Geodetic Engr., U. S. Coast and Geodetic Survey, Care, U. S. S. *Wenonah*, 202 Burke Bldg., Seattle, Wash........................ Nov. 21, 1921

MACKENZIE, RAY ELLIOTT. 103 Victoria Ave., Charlotte, N. C.... Jan. 16, 1922

MARSHALL, WILLIAM EDWARD. 1908 Penn Ave., Pittsburgh, Pa... Jan. 16, 1922

MELOY, THOMAS. Asst. to J. A. L. Waddell; Am. Member, Chinese Yellow Bridge Comm.. Bank de l'Indo Chine, Peking, China. Oct. 10, 1921

ROBINSON, PERCY RALPH. Asst. Engr., Sir William Arrol & Co., Ltd., 12 Edmund St., Rochdale, England................. Nov. 21, 1921

ROSS, KENNETH WARD. Designing Draftsman, George F. Hardy, 309 Broadway, New York City.......................... Oct. 10, 1921

THOMAS, CHARLES OSCAR. Res. Engr., Divisions 1 and 2, Little Rock Hot Springs Highway. Box 322, Benton, Ark......... Oct. 10, 1921

WADDINGTON, JOHN CROSSLEY. Chellow Dene, Barnsley Rd., Sheffield, England .... Nov. 21, 1921

REINSTATEMENTS

MEMBERS — Date of Reinstatement.

PRATT, MASON DELANO.. Jan. 16, 1922

REED, HENRY BUDD.. Jan. 16, 1922

ASSOCIATE MEMBERS	Date of Reinstatement.
Rea, Richard Willis	Jan. 16, 1922

RESIGNATIONS

MEMBERS	Date of Resignation.
Alexander, Henry David	Dec. 31, 1921
Boggs, Edward Marshall	Dec. 31, 1921
Conner, Arthur Watson	Dec. 31, 1921
Connor, William Durward	Dec. 31, 1921
Hendrick, Calvin Wheeler	Dec. 31, 1921
Jervey, Henry	Dec. 31, 1921
Leitch, John	Dec. 31, 1921
Lipsey, Thomas Eugene Leard	Dec. 31, 1921
May, Edward Abner	Dec. 31, 1921
Noble, Theron Augustus	Dec. 31, 1921
North, Arthur Tappan	Dec. 31, 1921
Phillips, William Renton	Dec. 31, 1921
Ripley, Joseph	Dec. 31, 1921
Roberts, Shelby Saufley	Dec. 31, 1921
Taylor, Benjamin Henry	Dec. 31, 1921
Tenney, Arthur Arnold	Dec. 31, 1921
Thornton, Charles James	Dec. 31, 1921
Zinn, George Arthur	Dec. 31, 1921

ASSOCIATE MEMBERS	
Allardice, Elliott Ritchie Barclay	Dec. 31, 1921
Barker, Edgar Earl	Dec. 31, 1921
Bowen, Edmund Ignatius	Dec. 31, 1921
Bowman, Ralph McLane	Dec. 31, 1921
Bradbury, Richard Robertson	Dec. 31, 1921
Bradley, William Littell	Dec. 31, 1921
Bunnel, William Cyrus	Dec. 31, 1921
Buzzell, Josiah William	Dec. 31, 1921
Campbell, Thomas Francis	Dec. 31, 1921
Canfield, George Hathaway	Dec. 31, 1921
Giquel, Rafael Sanchez	Dec. 31, 1921
Gray, Edward	Dec. 31, 1921
Gray, John Lathrop	Dec. 31, 1921
Hanique, Jules Edmond	Dec. 31, 1921
Harper, Isaac Onward	Dec. 31, 1921
Howland, Leon David	Dec. 31, 1921
Irvine, Frederick Brice	Dec. 31, 1921
Johnson, Harvey Stone	Dec. 31, 1921
Koester, Edwin Ferdinand	Dec. 31, 1921
Lee, Augustine Leftwich	Dec. 31, 1921
Lehfeldt, Walt Ferd	Dec. 31, 1921
Maier, Harry Ludwig	Dec. 31, 1921
Martin, Charles William	Dec. 31, 1921

ASSOCIATE MEMBERS—(*Continued*)

	Date of Resignation.
Michael, Herbert Ledlie	Dec. 31, 1921
Miller, Max Merrill	Dec. 31, 1921
Moses, Carroll	Dec. 31, 1921
Myers, Chester John	Dec. 31, 1921
Nelson, William	Dec. 31, 1921
Norton, John Evered	Dec. 31, 1921
Peabody, George Alfred	Dec. 31, 1921
Plumley, Stuart	Dec. 31, 1921
Rockwell, Harlow Loveridge	Dec. 31, 1921
Schenstrom, William Rolf Oscar Holmboe	Dec. 31, 1921
Shreve, Ralph Febrey	Dec. 31, 1921
Shute, James Selden	Dec. 31, 1921
Smith, Julien	Dec. 31, 1921
Sovereign, Harry Evans	Dec. 31, 1921
Stark, John Vassar	Dec. 31, 1921
Starkweather, Alfred Kenneth	Dec. 31, 1921
Stevenson, Ervin Beecher	Dec. 31, 1921
Tolman, Edward Mayo	Dec. 31, 1921
Towle, Foster	Dec. 31, 1921
Wallace, Edward Ewing	Dec. 31, 1921
Wright, Thomas Temple	Dec. 31, 1921

AFFILIATES

Brown, Joseph Henry	Dec. 31, 1921
Church, Howard Emerson	Dec. 31, 1920
Colby, Safford Kinkead	Dec. 31, 1921
Henry, Smith Tompkins	Dec. 31, 1921
Hughes, Harold Lincoln	Dec. 31, 1921
Olds, William Clarence	Dec. 31, 1921

JUNIORS

Baker, Avey Martin	Dec. 31, 1921
Bricklin, Simon	Dec. 31, 1921
Carey, Matthew Lawrence	Dec. 31, 1921
Christian, Valentine	Dec. 31, 1921
Godfrey, Alexander Hollis	Dec. 31, 1921
Hartline, William Raymond	Dec. 31, 1921
Kohl, Frank Edward, Jr.	Dec. 31, 1921
Lipari, Attilio Felix	Dec. 31, 1921
Oatman, Franklyn William	Dec. 31, 1921
Ostrom, Charles Douglas Yelverton	Dec. 31, 1921
Pride, Harold Ellwood	Dec. 31, 1921
Randolph, James Robbins	Dec. 31, 1921

DEATHS

Bell, Harold Ingersoll. Elected Associate Member, August 31st, 1915; died December 28th, 1921.

Blenus, Anson Morse. Elected Associate Member, July 6th, 1920; died January 5th, 1922.

DEATHS—(*Continued*)

KING, CLIFFORD MARSHALL. Elected Junior, March 6th, 1906; Associate Member, July 1st, 1909; died January 2d, 1922.

RUTH, ABRAHAM JOHN. Elected Associate Member, March 4th, 1913; died November 3d, 1921.

SELTZER, HARRY KENT. Elected Junior, February 4th, 1896; Associate Member, January 2d, 1901; Member April 3d, 1906; died December 30th, 1921.

THORNTON, EDMUND ABIEL. Elected Associate Member, November 4th, 1914; died January 9th, 1922.

TYSON, ANDERSON HARVEY. Elected Member, October 2d, 1889; died January 12th, 1922.

WHITAKER, DEBERNIERE. Elected Member, October 1st, 1912; died December 25th, 1921.

WRIGHT, CHARLES ALBERT LORING. Elected Member, October 10th, 1916; died August 17th, 1921.

Total Membership of the Society, January 31st, 1922, 10 263.

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST

Owing to pressure of work, due to the Annual Meeting, it has been necessary to omit this list in this issue. The items for both February and March will be published in *Proceedings* for March, 1922.

Vol. XLVIII. FEBRUARY, 1922. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852.

PAPERS AND DISCUSSIONS

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Vol. XLVIII. FEBRUARY, 1922. No. 2.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications.

CONSTRUCTION PROGRESS OF THE HETCH HETCHY WATER SUPPLY OF SAN FRANCISCO, CALIFORNIA

By M. M. O'Shaughnessy,* M. Am. Soc. C. E.

Synopsis

The Hetch Hetchy Water Supply Project is to make available to San Francisco, and the adjacent metropolitan area, 400 000 000 gal. of water daily, sufficient to satisfy the requirements of the district for a century to come. The incidental production of 200 000 hydro-electric horse power will make it also an important factor in the industrial progress of Central California.

The water is to be diverted from the Tuolumne River and some of its tributaries, in the Sierra Nevada Mountains, more than 150 miles from San Francisco on the aqueduct line. The project takes its name from its principal reservoir site, Hetch Hetchy Valley.

It is not intended in this paper to describe or discuss in detail the project as a whole, but to present a comprehensive view of the present stage of construction, making only such reference to the general scheme and matters of policy as appear necessary to an understanding of the development of the working program.

Historical

From its pioneer days, the Spring Valley Water Company has supplied San Francisco with water from local sources, owned or controlled by that Corporation. The most distant works now in use are, along the conduit lines, about fifty miles from the city. The approaching inadequacy of this supply has been evident for many years, and it was early recognized that the City must inevitably bring additional water from some more distant and more prolific source, which eventually will become the principal one, the

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* City Engr., San Francisco, Cal.

local works assuming the position of an auxiliary. Nearly every important stream in Northern and Central California has been proposed at one time or another as a possible source of the desired additional supply, and many of them have been the subject of engineering studies on which cost estimates have been made in considerable detail.

As early as 1879 the Upper Tuolumne River, with Hetch Hetchy Valley as a reservoir site, was suggested. In 1901, the Hon. James D. Phelan, then Mayor of San Francisco, filed water appropriation notices on the Tuolumne and its tributary, Eleanor Creek, and applied to the Secretary of the Interior for reservoir rights of way covering Hetch Hetchy Valley and Lake Eleanor, both of which lie in Yosemite National Park.

Opposition immediately developed, instigated primarily by corporate interests hostile to municipal ownership of public utilities, or financially interested in rival water-supply projects, and for twelve years progress was arrested by a well organized campaign of antagonism, with hostility by Federal officials to any encroachment in the Yosemite National Park. It was decided at last that special legislation would be necessary to grant the city the privileges it sought. Such legislation was enacted by Congress in December, 1913.

In the meantime, the people of San Francisco had declared themselves almost unanimously in favor of the project by voting, in 1908, a \$600 000 bond issue for the purchase of privately owned lands and water rights, and, in 1910, by voting a bond issue of \$45 000 000 to finance the construction.

In the spring of 1914, road work was begun, and, in the following July, the construction of a railroad to Hetch Hetchy Valley was commenced and a sawmill built. From that time, construction work has been pushed forward steadily, although until recently progress has been slow, due to the same difficulties of financing and obtaining labor and materials as were experienced by all large construction projects after the outbreak of the World War. A further handicap lay in a provision of the City Charter preventing the sale of the City's bonds at less than par. This was recently amended to allow the 4½% bonds already authorized to be sold on a 5½% basis.

Scope of the Project

The Hetch Hetchy System was first planned to supply San Francisco alone. The present scheme, however, is much broader. The cities on the eastern shore of San Francisco Bay and those south of the city on the peninsula are even more in need of an increased water supply than San Francisco. Therefore, the region west, east, and south of the Bay was considered as forming a Metropolitan Water District. The ultimate capacity for the Hetch Hetchy works was fixed at 400 000 000 gal. per day and takes into account the probable requirements of the district throughout the present century.

John R. Freeman, President, Am. Soc. C. E., assisted the representatives of the city in presenting their case before the Federal officials, and, in 1912, prepared preliminary plans and estimates, in some detail, for developing ultimately 400 000 000 gal. of water daily and transmitting it to the Metropolitan District. The project is now being carried out along the general lines

then suggested by Mr. Freeman, although with modifications as to a number of important features. An abstract of Mr. Freeman's report has been published.*

Important Changes in Policy from the Plans of 1912

The plans of 1912 contemplated an initial development of 240 000 000 gal. per day, the surplus over the needs of the Metropolitan District to be used for irrigation in the adjacent area. Certain irrigation districts of the San Joaquin Valley protested against such a diversion of water from the Sierra Nevada water-shed for the irrigation of other regions, so this feature of the project was abandoned, and the initial pipe lines were reduced to sizes adequate for the domestic water supply, but have not been finally determined, as definite plans for the formation of a Metropolitan Water District have not been developed.

Another important departure from the former plans is in the program for power development. The intention was that the construction of hydro-electric plants should follow the completion of the first aqueduct unit delivering Tuolumne River water to San Francisco. The local sources of the Spring Valley water supply, however, are capable of further development which will meet the needs of the city for at least ten years to come, therefore making the immediate delivery of Hetch Hetchy water unnecessary. On the other hand, electric-power development is of vital importance to the industries of California, and for many years the market will absorb new power as fast as it can be made available. It is to the advantage of San Francisco, therefore, to begin as soon as possible to generate the power which is a by-product of the water development, so that the revenue from power sales can be used to pay interest and redemption charges on bonds, reducing the burden to be carried by the taxpayers on the water project. A further and equally important reason for concentrating energy on the completion of the power project is that the water will thus be put to beneficial use and the water rights of the city thereby guarded.

General Program of Construction

The following general program of construction therefore has been adopted. The Hetch Hetchy Dam is to be built to about three-fourths of its ultimate height and thus develop about 60% of the ultimate reservoir capacity; the aqueduct between Early Intake and Moccasin Creek is to be completed, and the power plant on Moccasin Creek is to be constructed, in order to begin generating electric power at the earliest possible date. It is expected that the power plant will be in regular operation before the end of 1923.

A 23-mile section of the aqueduct is to be built between Alameda Creek and the Crystal Springs Reservoir of the Spring Valley System, and will probably be completed sometime in 1924. This will make available, without duplication of aqueducts, the additional Spring Valley water previously mentioned, and, later, will carry Hetch Hetchy water.

* *Engineering News*, December 26th, 1912, pp. 1207–1214.

Construction of the remaining parts of the aqueduct will follow in time to have Hetch Hetchy water ready for delivery when the demand has absorbed the additional available supply from Spring Valley sources, but will be deferred, of course, as long as prudence will permit, in order to minimize the financial burden.

Other units of the project will be built as required, to keep pace with increasing demands for water and power.

General Description of the Project

Maps.—The location and condensed profile of the Hetch Hetchy System, from the water-sheds to the receiving reservoir in San Francisco, are shown on Plate III. The region from the Hetch Hetchy and Lake Eleanor Reservoirs to the head-works of the main aqueduct is shown in detail in Plate IV, and the location of that part of the main aqueduct now under construction appears in Fig. 1.

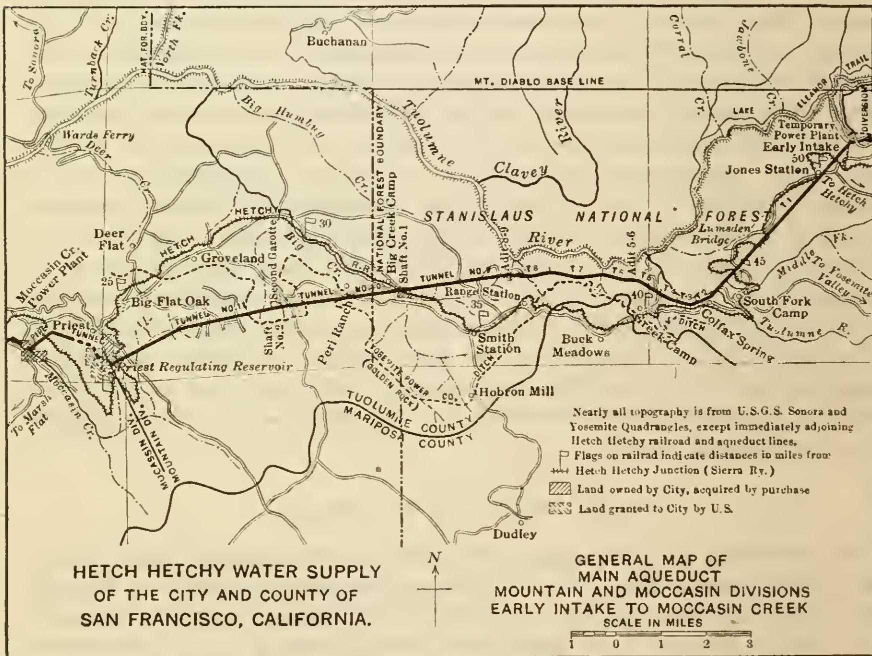
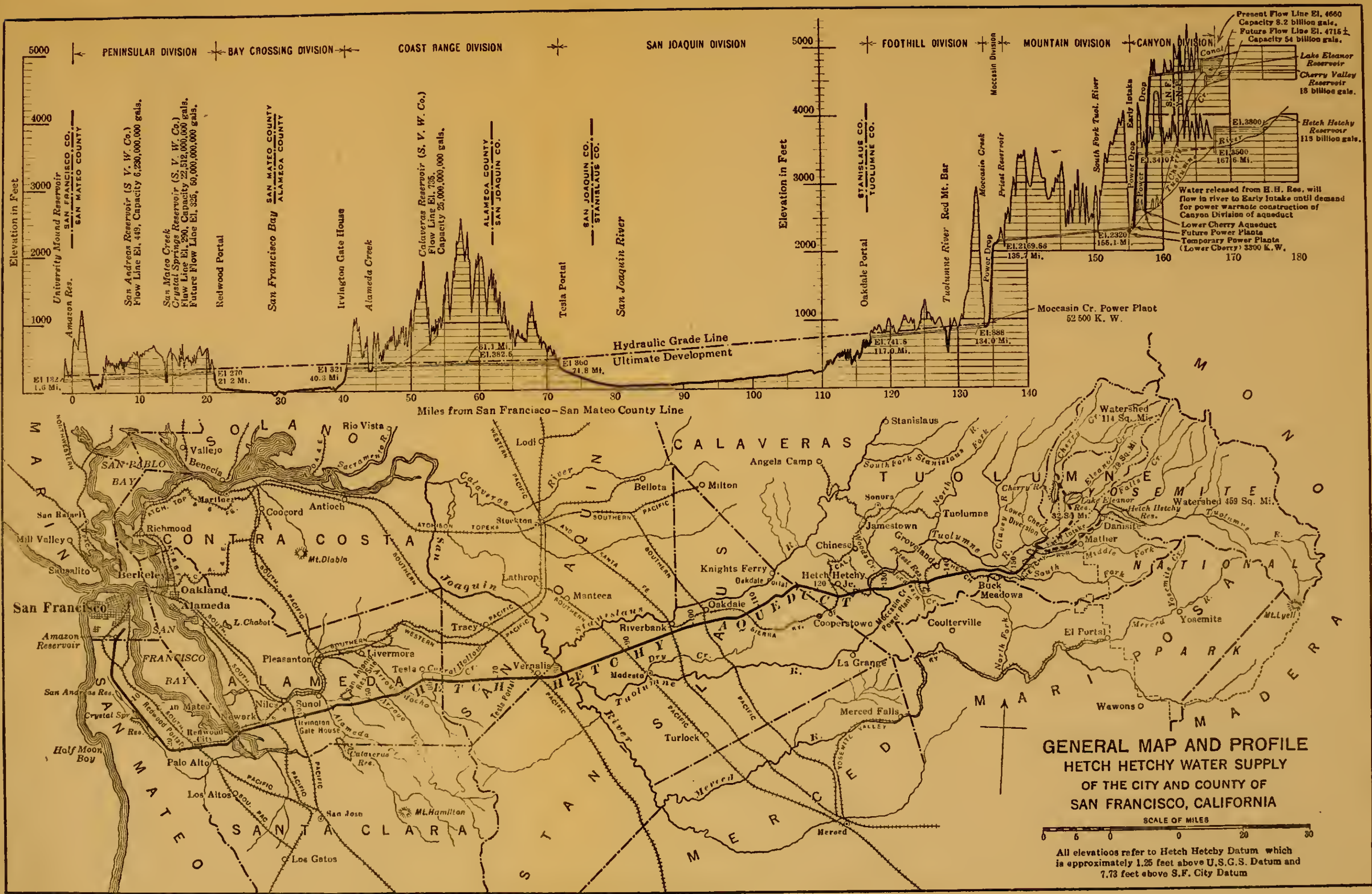
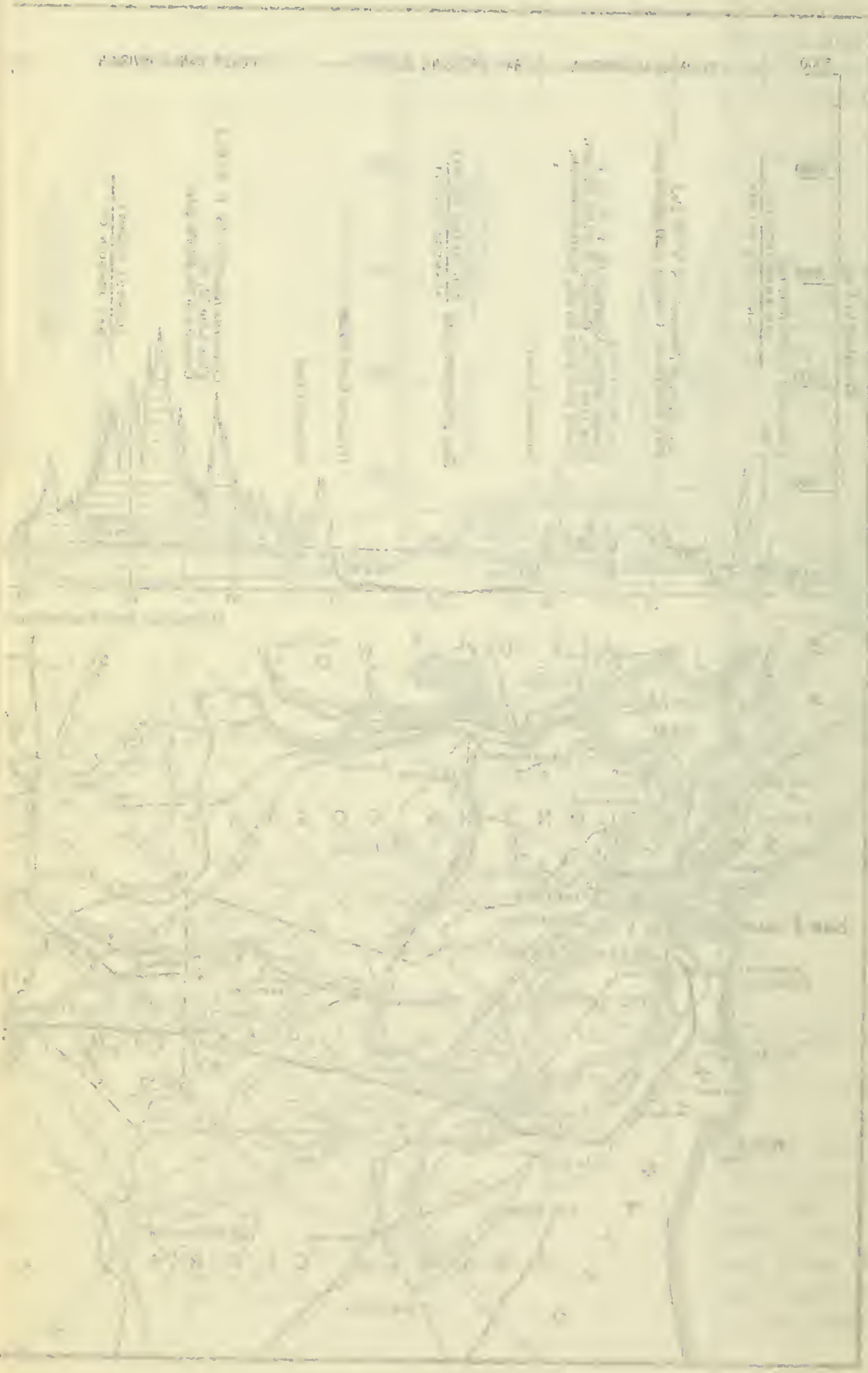


Fig. 1.

Water-Sheds.—The water-shed area tributary to the city's proposed impounding reservoirs on the head-waters of the Tuolumne River, covers 652 sq. miles in the high mountain region just west of the main ridge of the Sierra Nevada. Its elevation above sea level ranges from 3 500 ft. at Hetch Hetchy Dam to 13 090 ft. at Mount Lyell, 92% of the area being above Elevation 6 000. There are no permanent habitations, and the Congressional grant fixes sanitary regulations to prevent contamination of the water by summer camping parties.



GENERAL MAP AND PROFILE
HETCH HETCHY WATER SUPPLY
OF THE CITY AND COUNTY OF
SAN FRANCISCO, CALIFORNIA



The Hetch Hetchy and Lake Eleanor water-sheds, of 459 and 79 sq. miles, respectively, lie within Yosemite National Park. Yosemite Valley is 18 miles southeast of Hetch Hetchy, in the drainage basin of the Merced River, and is not affected by the water development.

Cherry Creek is to be made tributary to Lake Eleanor through a diversion canal and tunnel. (Plate IV.) Its water-shed lies in the Stanislaus National Forest, and covers 114 sq. miles.

Reservoirs.—Hetch Hetchy Reservoir, the elevation of which is 3 500 ft. at the original stream level, will have a total capacity, with a depth of 300 ft. at the dam, of 113 500 000 000 gal., or 348 000 acre-ft. In the initial development, however, the depth at the dam will be only 220 ft., storing 67 000 000 000 gal., or 206 000 acre-ft.

At Lake Eleanor, Elevation 4 600, a storage of 8 200 000 000 gal., or 25 300 acre-ft., has already been developed in connection with the construction power plant to be described later. The ultimate capacity at this site has been tentatively fixed at 54 000 000 000 gal., or 166 000 acre-ft.

Other reservoirs which may be developed later are: Cherry Valley, 18 500 000 000 gal.; Poopenaut Valley, 10 000 000 000 gal.; Lake Vernon, 16 600 000 000 gal.; Huckleberry Lake, 17 000 000 000 gal., and Emigrant Lake, 4 600 000 000 gal.

The Aqueduct in the Sierra Nevada.—In the initial development, the water released from Hetch Hetchy Reservoir flows twelve miles down the Tuolumne River to a diversion dam at Early Intake. (Plate IV.) The fall in the river in this distance is 1 160 ft., and later will be utilized for power development, by means of a tunnel aqueduct in the granite canyon wall, on the south side of Tuolumne River.

The North Mountain Aqueduct.—In order to develop the full power possibilities of Lake Eleanor, an 8-mile aqueduct, with a capacity of 200 sec-ft., is to be constructed, leading from the Lake to a power drop at which a head of 2 100 ft. will be available. (Plate IV.) This power unit will be capable of generating continuously about 25 000 kw. The water will be discharged into the Tuolumne River above the Early Intake diversion.

The Mountain Division of the Aqueduct.—The aqueduct now under construction begins at Early Intake. (Fig. 1.) From the diversion dam at that point there will be ½ mile of open canal with settling chambers, thence the water will be conducted through 18.3 miles of tunnel, discharging into the regulating forebay reservoir at Priest. This tunnel and all other tunnels of the main aqueduct are placed below the hydraulic grade line in order to operate under a light pressure head.

The Priest Reservoir will receive water at the rate of 400 000 000 gal. daily (619 cu. ft. per sec.), but will discharge at varying rates as required by the fluctuating load conditions at the power plant on Moccasin Creek. The reservoir will be formed by an earth and rock-fill dam 145 ft. high, with a concrete core wall. Its capacity will be 2 500 acre-ft., or 2 days' flow of the aqueduct.

An outlet tunnel, 1.3 miles long, will lead from this reservoir through a ridge to the head of the steel pressure pipe lines, each 4 700 ft. in length, which will supply the power plant on Moccasin Creek.

The Moccasin Creek Power Plant.—This power plant will have a 24-hour average capacity of 70 000 h. p. The maximum static head will be 1 315 ft. The initial installation will be three 20 000-kva. generating units, driven by double-overhung impulse water wheels.

Since the topography does not permit of the construction of forebay reservoirs above the other power plants of the System, these plants will be operated at a load factor of 100%, in the ultimate development, and the entire system will be regulated at Moccasin Creek, more generating units being added to care for peak loads; hence, the necessity for the unusually large forebay capacity to be provided in the Priest Reservoir.

The general layout for this plant was determined in 1914 after consultation with a board composed of the following engineers, F. G. Baum, M. Am. Soc. C. E., Professor William F. Durand, and John D. Galloway, M. Am. Soc. C. E.

The Foot-Hill Division.—The aqueduct running west from Moccasin Creek (Plate III) will be constructed, when it becomes necessary to supplement the Spring Valley water supply with water from Hetch Hetchy, and will begin at the tail-race reservoir from the power plant on Moccasin Creek, at Elevation 900. This reservoir will receive the water from the plant and regulate the flow through the aqueduct, which is a tunnel and extends about 17 miles to Oakdale Portal, in the foot-hills east of the San Joaquin Valley.

The tunnels so far mentioned are designed for a flow of 400 000 000 gal. per day, except the outlet tunnel from the Priest Reservoir, which is made larger in order to avoid excessive loss of head at the time of peak load on the power plant.

The San Joaquin Valley Pipe Line.—From Oakdale Portal, steel pipe lines will extend across the San Joaquin Valley, 45 miles to Tesla Portal. (Plate III.) The capacity of the first of these lines will depend on the development of the Metropolitan District, but is not likely to be less than 60 000 000 gal. per day. The final stage of the project will probably call for three lines nearly 7 ft. in diameter, each carrying 133 000 000 gal. per day. These pipes will be subjected to heads varying from 450 to 540 ft. for 70% of their length.

Coast Range Tunnel.—From Tesla Portal a tunnel will penetrate the Coast Range, a distance of 31 miles, to Irvington Gate House, a few miles east of San Francisco Bay. Here, the aqueduct will divide to serve the three main divisions of the Metropolitan Area; the principal branch will extend westerly to the San Francisco Peninsula, another, northwesterly to the East Bay cities, and the third southward to San Jose.

At the crossing of Alameda Creek, a few miles east of Irvington Gate House, the waters of the near-by Calaveras Reservoir of the Spring Valley System will be taken into the Hetch Hetchy Aqueduct.

The Bay Crossing Pipe Line.—To supply the San Francisco Peninsula, an ultimate capacity of 200 000 000 gal. per day is planned.

PLATE IV.
PAPERS, AM. SOC. C. E.
FEBRUARY, 1922.
O'SHAUGHNESSY ON
CONSTRUCTION PROGRESS
OF HETCH HETCHY WATER SUPPLY.

Continuing west from Irvington, more than 19 miles of pipe line are required in crossing the low land adjacent to San Francisco Bay to the high ground on the Peninsula west of the Bay. The initial line will probably have a capacity of 30 000 000 gal. per day, and will be used first to carry the additional supply from the Spring Valley sources, for which purpose pumping must be resorted to, as the Spring Valley Conduit, which delivers water near Irvington, is 200 ft. below the hydraulic grade line of the proposed Hetch Hetchy Conduit.

The head on the pipe will range from 300 to 365 ft. for 17 miles of its length and where the navigable channel of the Bay is crossed, special construction must be used, the type of which, for the full development of the aqueduct, has not yet been determined. In the initial stage submerged pipe with ball and socket joints will probably be used.

This connection ultimately will require three parallel pipe lines, each more than 6 ft. in diameter. The division terminates at a tunnel portal near Redwood City, called the Redwood Portal.

Connection to the Spring Valley System and to San Francisco.—The preliminary plans of the aqueduct from Redwood Portal to the receiving reservoir in San Francisco, a distance of 22 miles, call for a tunnel 10 ft. in diameter, broken at two places by siphons which total 2 miles in length.

The Crystal Springs Reservoir and two other reservoirs of the Spring Valley System lie near the aqueduct in this division. For the first stage of development, it is planned to construct about three miles of tunnel from Redwood Portal and establish a connection to Crystal Springs Reservoir, the capacity of which is 22 000 000 000 gal. The additional Spring Valley supply from Alameda Creek will then become available to San Francisco without further conduit construction being necessary for a few years, since the existing pipe lines of the Spring Valley System between Crystal Springs and San Francisco, with their booster pumps, are capable of furnishing more water than is now available in that System.

Receiving Reservoir in San Francisco.—The Hetch Hetchy Aqueduct will terminate in San Francisco at the proposed Amazon Receiving and Distributing Reservoir, which is to have a capacity of about 300 000 000 gal. Its high-water elevation will be 248 ft. above sea level. From this elevation, about half the supply can be distributed without pumping. Delivery by gravity at a higher elevation would unduly increase the cost of the aqueduct and would prevent the use of the Crystal Springs Reservoir in connection with the Hetch Hetchy supply.

Relation of the Spring Valley and Hetch Hetchy Systems.—It is the settled policy of the City Government to acquire all properties of the Spring Valley Water Company that are of permanent value for water supply purposes, and the plans for the Hetch Hetchy development provide for connections to co-ordinate the two systems and avoid the waste of duplication of structures. The distant supply would thus be combined with a local system which affords large storage for the waters from the distant source and which itself is a source of supply.

The proposition to purchase the local system has been made the subject of three elections, and has received an affirmative majority vote each time, but not the two-thirds majority necessary under the City Charter for consummation of purchase by approval of a bond issue.

Organization and Field Headquarters

The Hetch Hetchy water supply is under the jurisdiction of the Department of Public Works of San Francisco. The City Engineer is Chief Engineer of the Hetch Hetchy Project. His Principal Assistant directs all activities, and the headquarters engineering work is carried out by a branch of the City Engineer's office. In the field, two construction engineers report directly to the Project Engineer; one is located at Groveland and the other at Hetch Hetchy.

The general headquarters of the construction work in the mountains are located at Groveland, 27 miles on the City's Railroad from Hetch Hetchy Junction and 41 miles from Hetch Hetchy Valley. The Construction Engineer at Groveland has charge of the aqueduct work and is also Superintendent of the Hetch Hetchy Railroad. The Construction Engineer at Hetch Hetchy supervises the work on the Hetch Hetchy Dam and Reservoir and at Lake Eleanor, and the operation of the Mather saw-mill.

Hospital Service.—The City has provided a completely equipped hospital located at Groveland. The contractors are required either to avail themselves of the city's medical service for their employees, paying the city a fixed amount per employee per month, or to provide similar facilities at their own expense.

Shops.—The City's machine shops and car repair shop at Groveland handle practically all repairs in connection with the railroad operation and aqueduct construction, including heavy locomotive work. Several complete railway cars have been constructed in these shops.

Description of Construction Work Completed and in Progress

Following the general program already outlined, all construction activities thus far undertaken have been concentrated in the Sierra Nevada region between Lake Eleanor and Hetch Hetchy Reservoirs and Hetch Hetchy Railroad Junction, a distance of 80 miles.

Immediately after the President signed the Hetch Hetchy grant, work was begun to open up transportation facilities in the mountains. Pending the construction of a railroad, the existing roads were improved and relocated, and additional roads were built to Hetch Hetchy and Lake Eleanor, which were previously accessible only by horse trails.

To give access to Hetch Hetchy Valley, the 9 miles of railroad grade from Mather was rushed to completion in 1914, while surveys for the remainder of the line were still in progress. Most of the heavy hauling over the 55 miles of road from Chinese, the nearest railroad station, to Hetch Hetchy, was done under contract by motor trucks, at from 40 to 60 cents per ton-mile, the

rate depending mainly on the condition of the roads. For four months of the year, heavy hauling was prevented by the impassable condition of the dirt roads.

The Hetch Hetchy Railroad

All construction supplies are now transported to Oakdale (Plate III) on the Southern Pacific or Santa Fe Lines, and are there transferred to the Sierra Railway of California. Hetch Hetchy Junction, the initial point of the city's railroad, is 26 miles from Oakdale, on the Sierra Railway. The Hetch Hetchy Railroad extends 68 miles easterly from the junction to the construction camp at Hetch Hetchy Dam, known by the station name of Damsite. The air-line distance between the termini is about 40 miles.

The railroad serves the working points of the thirty miles of main aqueduct east of the Sierra Railway, the power development on Moccasin Creek, and the City's saw-mill, some directly, others through short spur-tracks, tramways, or motor-truck hauls.

The Hetch Hetchy Railroad was constructed under two contracts, one let in 1914, covering the grading of the 9 miles from Mather to Hetch Hetchy; the other was carried out in 1916 and 1917, covering all grading, track work, and other construction necessary to complete the railroad from Hetch Hetchy Junction to Damsite.

The Lower Cherry Power System

A temporary power plant located at Early Intake generates electric power for all the construction work from the Hetch Hetchy Dam to Moccasin Creek. Water is diverted from Cherry River into a conduit, 3½ miles long, which has a capacity of 200 sec-ft.

There are three horizontal Pelton-Francis turbines, each designed to operate at 720 rev. per min., and to develop 1 500 h. p., under a maximum head of 345.5 ft. The generators which are direct connected to the turbines, are 2 300-volt, 3-phase, 60-cycle machines, each of a rated capacity of 1 000 kva., with direct-connected exciters.

Two transmission lines conduct the power to the construction work. One line extends 14.5 miles east to the Hetch Hetchy Dam, and the other 19 miles west along the main aqueduct line to Priest, with a 2-mile branch to Groveland.

To insure sufficient water to operate the plant over the dry season, when the natural flow of the Cherry River shrinks to almost nothing, the Lake Eleanor Dam, described subsequently in this paper, was built.

Hetch Hetchy Dam

The Hetch Hetchy Dam is being constructed in two installments. Some of the principal dimensions of the initial and the ultimate stages are given in Table 1. The initial dam is now under construction under a contract awarded in August, 1919, to the Utah Construction Company.

TABLE 1.—STATISTICS OF HETCH HETCHY AND LAKE ELEANOR RESERVOIRS.

	HETCH HETCHY RESERVOIR.		LAKE ELEANOR.	
	Initial.	Ultimate.	Present.	Ultimate.
Area of water-shed, in square miles	459	459	79	183*
Capacity of reservoir:				
In millions of gallons	66 000	112 000	8 200†	54 000†
In acre-feet	202 000	343 000	25 300	167 600
Water surface area, in square miles	2.5	3	1.5	2.2
Elevation of roadway on dam, in feet	3 726.5	3 812	4 661	4 785
Elevation of spillway crest, in feet	3 719.75	3 800	4 660‡	4 775
Length of reservoir, in miles	7.5	8	3.1	3.2
Width of reservoir, maximum, in miles	0.65	0.7	1.0	1.1
Width of reservoir, average, in miles	0.33	0.38	0.5	0.7
Depth of reservoir from spillway crest:				
Maximum, in feet	220	300	60†	175†
Average, in feet	128	172	27†	119†
Dam:				
Type of dam	Concrete, gravity section, arched in plan.		Reinforced concrete buttressed arch.	Rock-fill with concrete facing.
Total length on crest, in feet	600	900	1 260	1 750
Height of crest above stream level, in feet	226	312	60	185
Depth from stream level to bed-rock, at toe of dam, maximum, in feet	101	101	Stream bed is solid rock	
Total height of dam, above bed-rock, in feet	327	413	70	....
Width at top, in feet	15	25	....	....
Width at base, maximum, in feet	310	310	....	....
Volume of masonry, in cubic yards	400 000	660 000	11 640	....
Type of spillway	Siphon.	Channel around end of dam.	Overflow.	Channel around end of dam.

* Includes Cherry Creek water-shed above proposed diversion.

† Lake Eleanor depths and capacities do not include original lake, which is not available for draft.

‡ With flash-boards in place; 4 655 ft. without flash-boards.

The addition necessary to bring the dam up to its ultimate height and thickness will be made when the demands for water or for electric power justify it. The present construction includes all work below stream level necessary for the ultimate structure.

Design.—The dam is to be of the gravity type, arched in plan, with the radius of the up-stream face at the crest 700 ft. The cross-section, at the maximum section, is shown in Fig. 2.

Most of the dam will be of 1 : 3 : 6 concrete embedded with large stones. For the concrete against the foundation, the cut-off trench, the up-stream face, and the down-stream face in the spillway section, a 1 : 2½ : 5 mixture is to be used to give greater impermeability.

The limiting working stresses in the design were as follows:

Pressure normal to joint, up-stream toe:
- Reservoir empty .... 25 tons per sq. ft.
- Reservoir full .... 16 tons per sq. ft.

Maximum pressure in section, under worst combination of conditions and lasting for comparatively short periods of time .... 27.5 tons per sq. ft.

No tension was permitted in the concrete. On each joint, upward water pressure was considered as acting at the up-stream face with an intensity of

two-thirds the total hydrostatic head and diminishing uniformly to zero at the down-stream face. On the foundation joint, an upward pressure of two-thirds the hydro-static head due to the back-water was also considered.

The dam is to be penetrated by a system of inspection tunnels, inspection wells, and drainage wells. The inspection wells will be lined with dense concrete blocks and equipped with ladders. The drainage wells will be in porous concrete blocks and will be 15 in. square.

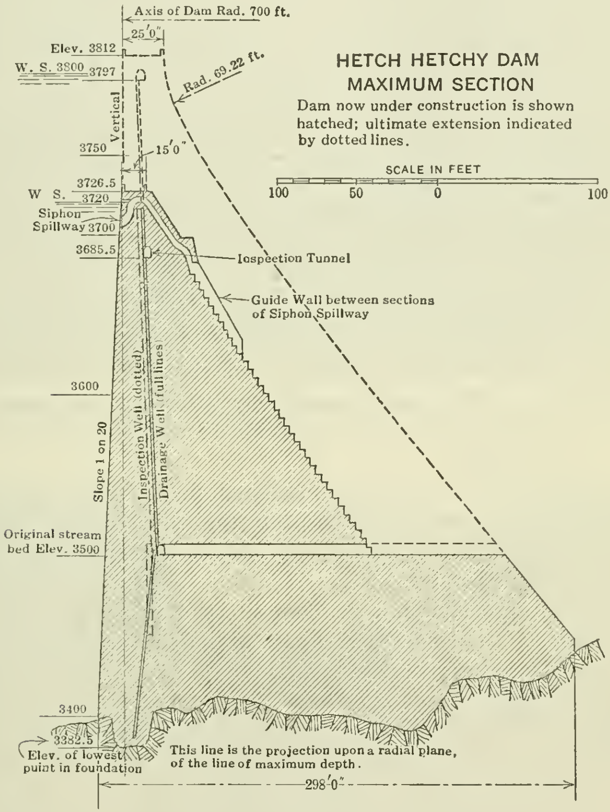


Fig. 2.

Radial contraction joints, sealed by bent copper water-stops, are provided at intervals of about 100 ft., measured along the up-stream face. Each contraction joint bisects an inspection well. The crest of the dam will be used as a roadway, in both the initial and ultimate developments. The stresses in the typical dam section were checked in 1917 by Charles B. Wing, M. Am. Soc. C. E., and C. D. Marx, Past-President, Am. Soc. C. E.

Spillway.—The ultimate dam will have a spillway of the weir type, with a channel to carry the waste water around one end of the dam. A siphon spillway has been adopted for the initial dam, and will be in eighteen sections, staggered in elevation to obviate vacuum effects, with a total length of clear openings of 180 ft. 6 in. Each section will be 8 ft. high at the entrance,

tapering to 4 ft. at the crest of the siphon, and will have two air vents, each 12 by 24 in.

Outlet System.—There will be twelve outlet conduits, six of which will be each 5 ft. in diameter, and arranged in pairs at three levels. These will discharge water (in quantities up to 3 000 sec-ft.) which under certain conditions of river flow is permitted to pass the dam for the use of irrigation districts in the lower reaches of the Tuolumne River. Each of the other six outlets will be 3 ft. 6 in. in diameter, in two groups of three, and will discharge the water for the city supply. The smaller outlets will ultimately discharge directly into the aqueduct tunnel to be constructed in connection with the future power development at Early Intake, whereas the water for irrigation may flow directly down the bed of the river.

The discharge in each conduit will be regulated by balanced needle-valves with the Larner-Johnson type of control. At the entrance to the conduit, there will be a slide-gate with hydraulic cylinder operation. A heavy reinforced concrete shutter may be lowered through a slot in the wall of the outlet structure to close the opening on the up-stream side of the slide-gate, thus providing access to the gate for inspection or repairs.

Construction of Hetch Hetchy Dam

Excavation to the bed-rock foundation of the Hetch Hetchy Dam was completed in August, 1921, and immediately afterward the pouring of the concrete was commenced. It is the intention to pour nearly 400 000 cu. yd. of concrete in 16 months.

Stream Control.—The maximum measured flood flow of the Tuolumne River at the dam site, during the ten years for which records are available, was 12 700 sec-ft., and the stream-control works were planned for approximately that quantity of water.

The river is by-passed around the dam site through a tunnel, 23 ft. wide, 25 ft. high, and 900 ft. long. The lower group of three 3 ft. 6-in. outlet conduits will be placed later in this tunnel.

The diversion dam is a rock-filled crib, 321 ft. long, of 12 by 12-in. timbers. The up-stream face is sheathed with a double layer of 2-in. plank, with a layer of tarred burlap between. A maximum head of 13 ft. over the top of the tunnel was provided to dispose of the flood waters. This structure was designed by J. Q. Barlow, M. Am. Soc. C. E., Consulting Engineer for the Utah Construction Company.

A concrete dam was built just up stream from the lower portal of the diversion tunnel, to prevent water discharged through the tunnel from backing up into the dam site. This dam was founded on boulders and coarse gravel, and is 51 ft. long on top. Its foundation was grouted to secure water-tightness.

Excavation for Foundations.—A steam shovel was used for the greater part of the excavation in the dam site, loading directly into dump cars. (Fig. 3.) When the space became too cramped to permit steam-shovel operation, the final 20 000 yd. was loaded into the skips by hand. The skips were emptied into trains running on trestles along the north and south walls of the gorge.

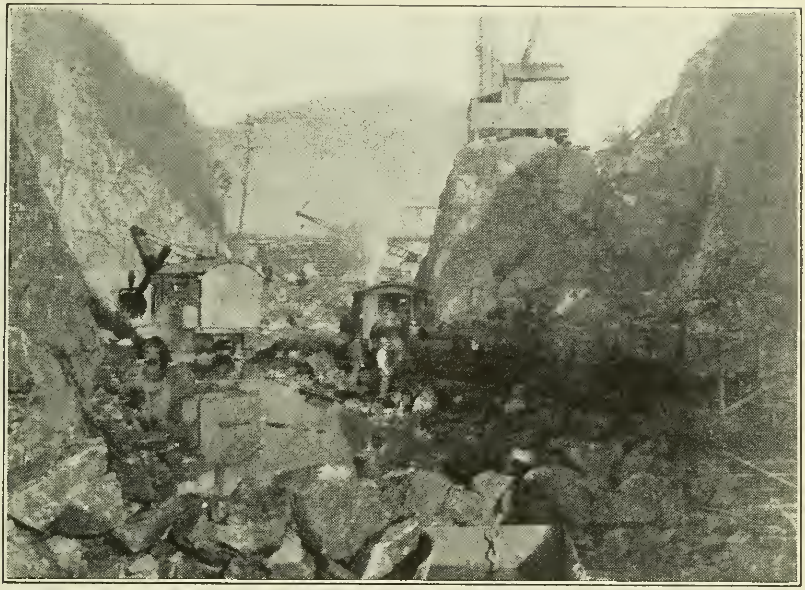


Fig. 3.—Excavating in Hetch Hetchy Dam Site at Stream Bed Level. Crib Division Dam in Background.

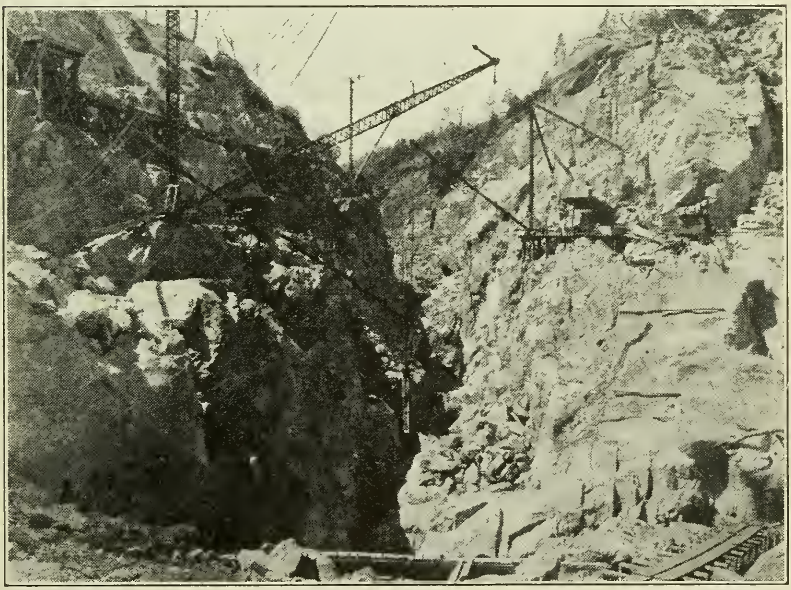


Fig. 4.—Hetch Hetchy Dam View Looking Down Stream. Excavation Practically Completed.

(Fig. 4.) The total excavation for foundations was 165 000 cu. yd., of which 100 000 cu. yd. was solid rock. The trains dumped the material on the floor of the valley, and much of the dumped rock will be used for concrete aggregate. Large rock fragments and boulders were placed by derricks on convenient corners and ledges for storage until required for plums in the cyclopean masonry. The lowest point in the foundation is 113 ft. below the original stream bed.

Nearly all the surface rock in the foundation above the stream level was removed, leaving a newly broken granite surface to receive the concrete, but below that level, where the rock had not been exposed to weathering, the trimming covers a much smaller proportion of the whole surface. The underlying formation is very tight. The foundation below the former stream level is being prepared to receive the concrete, largely by sand blasting which removes scale and soft pits satisfactorily and roughens the polished surfaces. Loose sand and dust are removed by washing and brushing with wire brushes. A more detailed description of the methods of stream control and excavation has already been published.*

Concrete Plant.—Bulk cement is delivered in box cars on a siding just above the dam site, and is unloaded into a hopper by means of a scraper drawn by a small motor-driven hoist. Screw conveyors carry it from the hopper to a storage bunker which has a capacity of 15 000 bbl., and two similar conveyors extend from the bunker to the weighing house, in which are two automatic weighing machines. The machines discharge by gravity through 8-in. pipes to the two 2-yd. mixers.

The rock crushers and sand pits are located in the valley. The rock and sand are hauled on a narrow-gauge railway to bunkers near the work, and lifted by belt conveyors into bunkers above the mixers. These bunkers discharge by gravity into the measuring boxes and thence to the mixers.

The elevator tower is built just up stream from the up-stream face of the dam, at the former stream bed level. It is a timber structure, 180 ft. high, with four hoists. The concrete is distributed through steel chutes.

Contract Prices.—The contract for the construction of the Hetch Hetchy Dam was awarded on August 1st, 1919, to the Utah Construction Company, at a total estimated price of $5 447 792. The principal items are as given in Table 2.

TABLE 2.

Excavation in dam foundation.	Approximate quantities, in cubic yards.	Unit Prices:	
		Below original stream bed.	Above original stream bed.
Earth and loose rock	65 000	$8.00	$1.50
Solid rock	100 000	11.20	3.00
Cyclopean masonry, 1: 3: 6: concrete with at least 10% of plums	330 000	11.80	11.00
Mass concrete, 1: 2½: 5	70 000	15.00	14.30

* *Engineering News-Record,* August 11th, 1921, p. 222.

Lake Eleanor Dam

Lake Eleanor is ultimately to be the second largest reservoir of the Hetch Hetchy System. In order to provide storage to carry the Early Intake power plant of the Lower Cherry Development over the annual low-water season, a low dam was constructed on the site of the future high dam, and will form the up-stream toe of the future structure. Characteristics of the Lake Eleanor development are given in Table 1.

The topography of the site necessitated a rather long structure, but other conditions were unusually favorable. The bed-rock was exposed throughout, sand and gravel deposits lay close at hand, and form lumber was manufactured near the work.

Design of the Dam.—Speed of construction, with minimum transport of material, was essential to impound sufficient water to operate the power plant during the dry season of 1918. These considerations led to the choice of a dam of the buttressed arch type.

The completed structure is 1 260 ft. long, the maximum height being 70 ft. above the stream bed. The maximum depth of water at the up-stream face is 60 ft. The dam contains 11 640 cu. yd. of concrete and 262 000 lb. of reinforcing steel. There are twenty arches of 40-ft. span and 460 ft. of gravity wall. Of this wall, 200 ft. is constructed as a spillway, with removable flash-boards. A log chute is also provided in this section. Over the dam is a reinforced concrete slab roadway, 12 ft. wide, with galvanized-iron railings.

The stored water is withdrawn through two 24-in. sluice valves, placed on the face of the dam. In addition, two 24-in. scouring valves are placed at the bottom of the dam.

The face of the arch is inclined at an angle of 50° from the horizontal, except the upper 7 ft., which is vertical. The radius of the arch barrel is 23 ft. in the horizontal section. The thickness normal to the face is about 3 ft. at the bottom and 15 in. at the top. An unusual feature of the design is that the horizontal section of the arch, and not the normal section, is a circular arc.

The dam was designed under the writer's direction by R. P. McIntosh, Hydraulic Engineer, assisted by R. J. Wood, Structural Engineer. Lars R. Jorgensen, M. Am. Soc. C. E., Consulting Engineer, and L. H. Nishkian, Assoc. M. Am. Soc. C. E., Structural Engineer, also collaborated. The analysis of the principles of the design has been given in a paper by Mr. McIntosh.*

Construction of the Lake Eleanor Dam.—Construction was carried out by day labor. Excavation in the foundation was commenced on September 1st, 1917, and continued to completion with the use of hand derricks. The foundations for the arches and buttresses vary from 5 to 15 ft. in depth below the surface.

Form work followed the excavation closely and concrete pouring in the footings was started on November 4th, 1917. The endeavor was to build the dam to a height, before a heavy snowfall, sufficient to enable construction to

* *Engineering News-Record*, September 4th, 1919, p. 464.

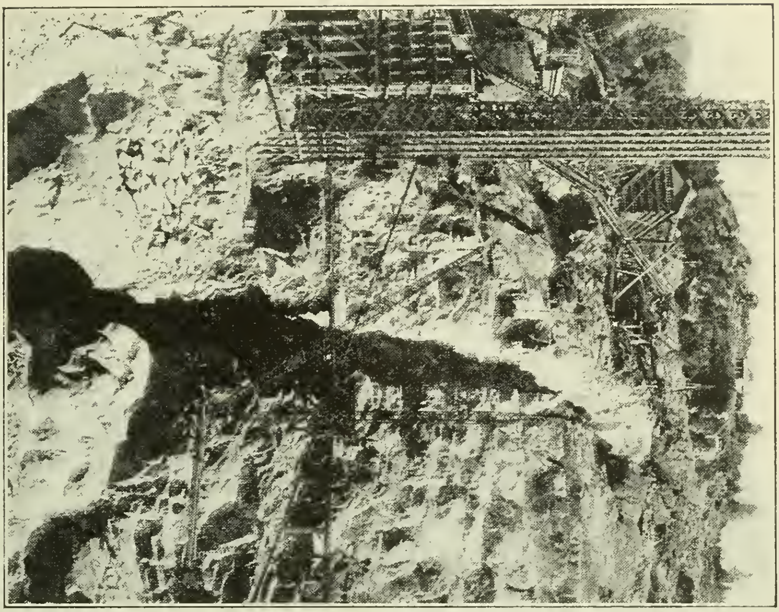


FIG. 5.—SOUTH ABUTMENT, HETCH HETCHY DAM, AFTER COMPLETION OF EXCAVATION.

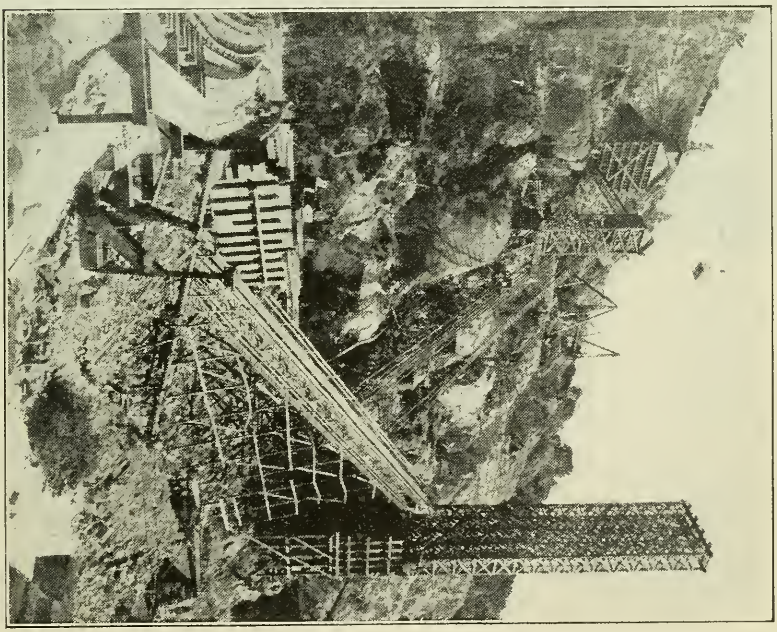


FIG. 6.—CONCRETE PLANT, HETCH HETCHY DAM CONSTRUCTION.

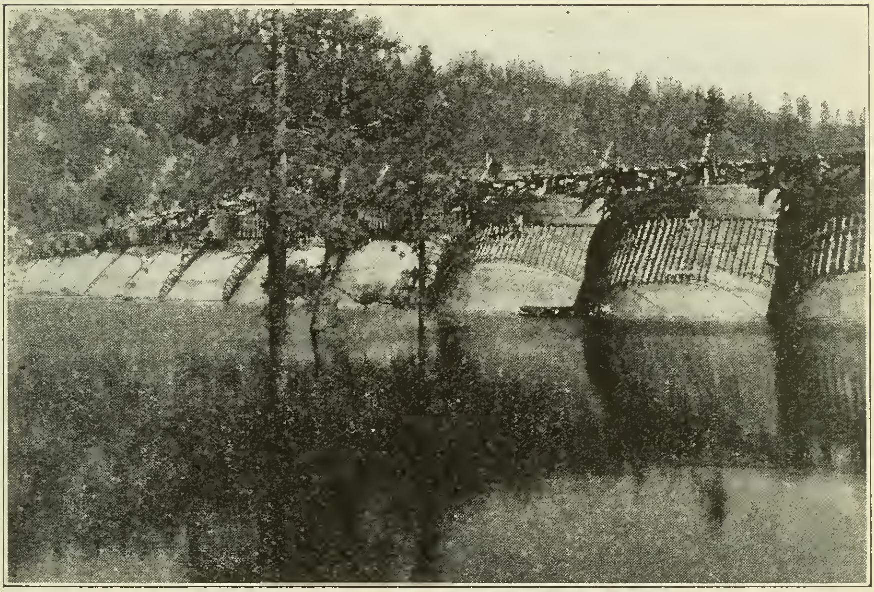


FIG. 7.—LAKE ELEANOR DAM NEARING COMPLETION.

proceed in the following spring without interference from the anticipated flood waters. Concrete pouring was continued until December 22d, 1917, and six temporary 4 by 2½-ft. openings were left in the face of the dam through which floods could pass. From December 22d, 1917, until April 22d, 1918, all work was shut down.

At the sand and gravel pits, traps were built of sufficient height to permit of the installation of screens and the loading of trucks by gravity. The sand and gravel were delivered to large bunkers, slightly higher than the crest of the dam. Under the bunkers, narrow-gauge side-dump cars were operated by gravity to a 1-yd. mixer on the crest of the dam. The mixer discharged into 1-yd. bottom dump cars which were handled to and from the concrete-placing chutes by endless cables, operated by single-drum steam hoisting engines.

The arch forms were carried up in sections about 10 ft. in height. Trestle work to support the forms was raised in bents 20 ft. in height, as the work progressed, to a point 8 ft. above the floor-slab.

The up-stream face of the dam was finished with a ¾-in. coat of gunite. The dam was completed late in 1918, but had already been put to use for storage of water to operate the Lower Cherry Power Plant. The entire cost of the structure was about $320 000, including the cost of a 12-mile wagon road from Hetch Hetchy, which was $28 000.

The reservoir capacity, which is about 25 300 acre-ft., is only a small part of the annual run-off from the Lake Eleanor water-shed, and the reservoir is filled each year early in the flood season.

The Aqueduct Tunnel

Construction work is well advanced on the 18.3 miles of main aqueduct in tunnel between Early Intake and the regulating reservoir at Priest. This tunnel is to carry 400 000 000 gal. per day, or 619 cu. ft. per sec., the ultimate development of the Hetch Hetchy Project.

The easterly 6 miles is through very hard, sound granite and granodiorite, and is to be left unlined except at a few points where seams have been encountered.

The greater part of the remaining 12 miles is in a slate formation, with its strike generally at an angle of less than 45° from the tunnel line, and with very steep angles of dip. The rock, in general, stands well, only occasional short stretches requiring timbering, but it is blocky and seamy, giving a large overbreak. Concrete lining of a minimum thickness of 6 in. will be used throughout this section. Where the external pressure due to heavy ground or water requires it, the lining must be strengthened to resist such pressure, by increasing the thickness of concrete, or by the use of steel reinforcement, or both. The standard lined section shown in Fig. 8 has the following properties:

Area of inside of prescribed line, in square feet............	105.63
" " " " lining (A), in square feet...............	87.94
" " concrete inside of prescribed line, in square feet....	17.69

Excavation inside of prescribed line, in cubic yards per linear foot	3.912
Concrete inside of prescribed line, in cubic yards per linear foot	0.655
Perimeter, inner side of lining (p), in feet	33.79

Hydraulic Elements:

Hydraulic radius $\left(r = \frac{A}{p}\right)$	2.60
" slope (S)	0.00121
Coefficient of roughness in Kutter's formula (n)	0.014
C, in Chezy formula	125.5
Velocity of water ($v = C\sqrt{r\ s}$), in feet per second	7.04
Quantity of water flowing ($Q = Av$), in cubic feet per second.	619.0

The standard unlined tunnel section shown on Fig. 9, has the following properties:

Cross-sectional area inside of prescribed line, in square feet. .	167.8
Excavation inside of prescribed line, in cubic yards per linear foot	6.21

Hydraulic Elements:

Wetted perimeter (p), in feet	48.0
Hydraulic radius $\left(r = \frac{A}{p}\right)$	3.50
Hydraulic slope (S)	0.00118
Coefficient of roughness in Kutter's formula (n)	0.032
C, in Chezy formula	57.4
Velocity of water ($v = C\sqrt{r\ s}$), in feet per second	3.69
Quantity of water flowing ($Q = Av$), in cubic feet per second.	619

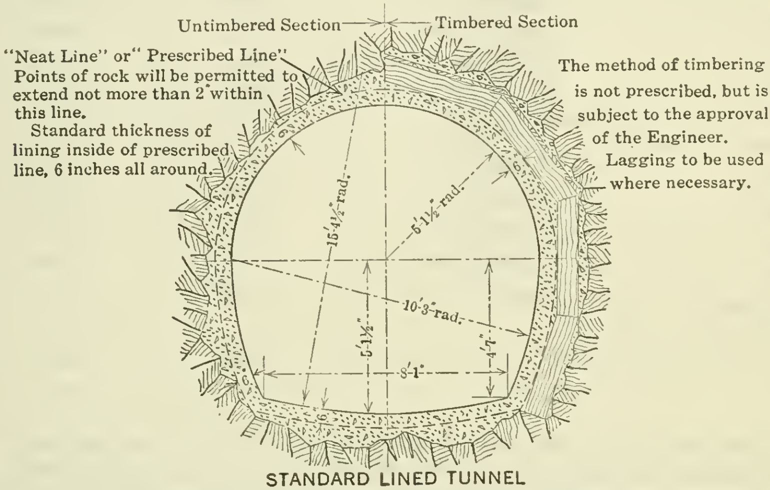
The Hazen-Williams formula, using $C = 485$, gives the same values for Q and v.

Description of the Tunnel Line.—The tunnel is divided by a river canyon into eleven sections, seven adits, and two shafts. (Fig. 1.) For convenience, each section has been given a number as a separate tunnel. Each adit is named by the numbers of the two tunnels to which it connects. The distances between points of access are as given in Table 3.

Tunnel No. 1 penetrates a ridge the summit of which is 1 750 ft. above the tunnel grade, between the main Tuolumne River and its South Fork. The latter stream will be spanned by a reinforced concrete aqueduct structure. Tunnel No. 1 is being excavated from both portals.

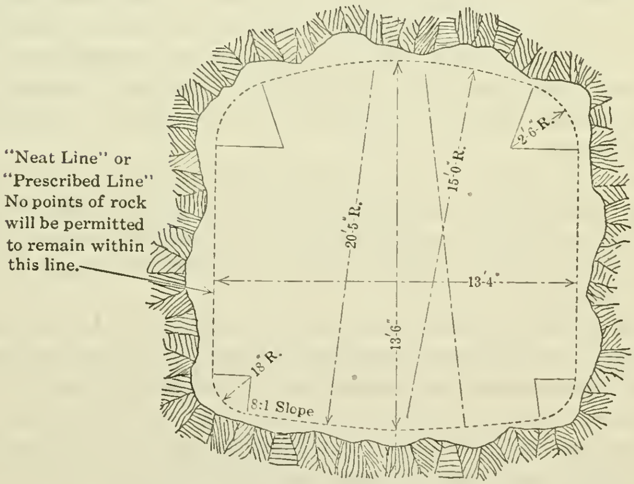
The line thence follows along the south wall of the river canyon to Adit 8-9, and is in from the surface only far enough to assure sound rock and sufficient cover at all points to resist the internal hydrostatic pressure. The work in this distance is being carried on from the west South Fork portal and Adits 5-6 and 8-9. The other five adits will be used only for ventilation and dumping.

At Adit 8-9, the river turns sharply to the north. The aqueduct, leaving the canyon, continues 9 miles westerly, at an average depth of about 1 000 ft. below the surface, to Priest Portal. This section is broken by two shafts, and will be lined throughout with concrete. Excavation is progressing in both directions at Shaft No. 1, and easterly from Priest Portal. At present, Shaft No. 2 is only 65% completed.



MAIN AQUEDUCT—MOUNTAIN DIVISION

Fig. 8.



MAIN AQUEDUCT—MOUNTAIN DIVISION
STANDARD UNLINED TUNNEL

Fig. 9.

Tunnel lining will not be commenced in any heading until the completion of the excavation in the heading, in order to avoid interference of operations. The concrete is to be placed by a pneumatic method.

TABLE 3.—LENGTHS OF SECTIONS OF HETCH HETCHY AQUEDUCT TUNNEL.

Point of access.	Designation of section.	Length, in feet.	Length, in miles.
Early Intake Portal.			
	Tunnel No. 1.........	23 698	4.488
South Fork Portal.			
	Tunnel No. 2.........	3 010	0.570
Adit 2-3.			
	Tunnel No. 3.........	1 783	0.338
Adit 3-4.			
	Tunnel No. 4.........	2 164	0.410
Adit 4-5.			
	Tunnel No. 5.........	2 785	0.527
Adit 5-6.			
	Tunnel No. 6.........	4 362	0.826
Adit 6-7.			
	Tunnel No. 7.........	5 676	1.075
Adit 7-8.			
	Tunnel No. 8.........	4 964	0.940
Adit 8-9.			
	Tunnel No. 9.........	12 472	2.362
Shaft 1.			
	Tunnel No. 10.........	15 320	2.902
Shaft 2.			
	Tunnel No. 11.........	20 489	3.880
Priest Portal.			
....	....	96 723	18.318

Cost-Plus-Fee-Contract.—In August, 1917, bids were received for constructing the aqueduct tunnel from Early Intake to Priest Reservoir, but were rejected as excessive. Since it was improbable that better bids could be secured by re-advertising during the period of the World War, under the uncertain conditions then existing as to labor and material costs and financing, the work was taken up by day labor. This system proved economical, and would have been continued but for the ever-increasing difficulties of financing.

Bids were again received in April, 1920. The cost records and other information gained during the previous two years were made available to prospective bidders.

Although it has always been, and still is, the policy of the City to award contracts for construction on the definite unit price basis, the advantages of the cost-plus-fee form of contract, under the abnormal conditions then prevailing, led to alternative bids being sought under both the unit price and cost-plus-fee plans.

The total of the guaranteed maximum costs of work under the cost-plus-fee form of contract proved to be nearly 20% less than on the flat unit price basis. Accordingly, the contract was awarded on the cost-plus-fee basis.

In this contract, the contractor guarantees that the costs of the respective items of the work will not exceed the unit prices fixed in his bid as maximum unit costs. He is not made fully responsible for excess over these maximum costs, but is only penalized to the extent of a part of his fee, which, however, amounts to a sufficient sum to give him a lively interest in holding down costs.

The total fee is a fixed sum. A part is payable at the beginning of each year of the life of the contract, to cover the expense of financing the year's work. The remainder is payable in quarterly installments. Of each quarterly

installment, 25% is retained by the City until the termination of the contract, and the accumulation of these retentions is the maximum sum that the contractor is to forfeit if the costs exceed the guaranteed maxima.

Detailed cost records are kept by the City's accounting force, and the contractor has the right to examine these records at any time. The determination of costs under the contract items, for comparison with the guaranties, is to be made annually. General costs not directly chargeable to particular items, and the fee itself, will be apportioned *pro rata* to the items. The legality of this form of contract was questioned in a taxpayer's suit, and was affirmed by the Supreme Court of the State of California.

The total of the guaranteed maximum prices under the contract, as awarded, was $7 802 952. The guaranteed maximum costs per foot average about $67.50 for unlined and $82.50 for lined tunnel.

Tunnel Excavation Methods and Equipment.—In all the tunnels the "round" covers the entire face. The spacing and pointing of the holes varies somewhat in the different headings, partly because of the differences in formation, and partly because better results are obtained by allowing some latitude to the foreman at each tunnel camp. Fig. 10 shows the drilling diagram for the two South Fork headings which are in hard, fine-grained granodiorite. Here, forty-two holes are used, and are shot in six stages by means of delay-action electric exploders.

After shooting, the muck is cleared from the upper half of the face, holes are drilled in the side-walls, and a staging is constructed, supported on bars inserted in the side-holes. Drilling in the upper half then proceeds simultaneously with the mucking. Mucking machines are used in all headings, and 4 and 5-ton electric storage battery locomotives are used to haul the muck trains.

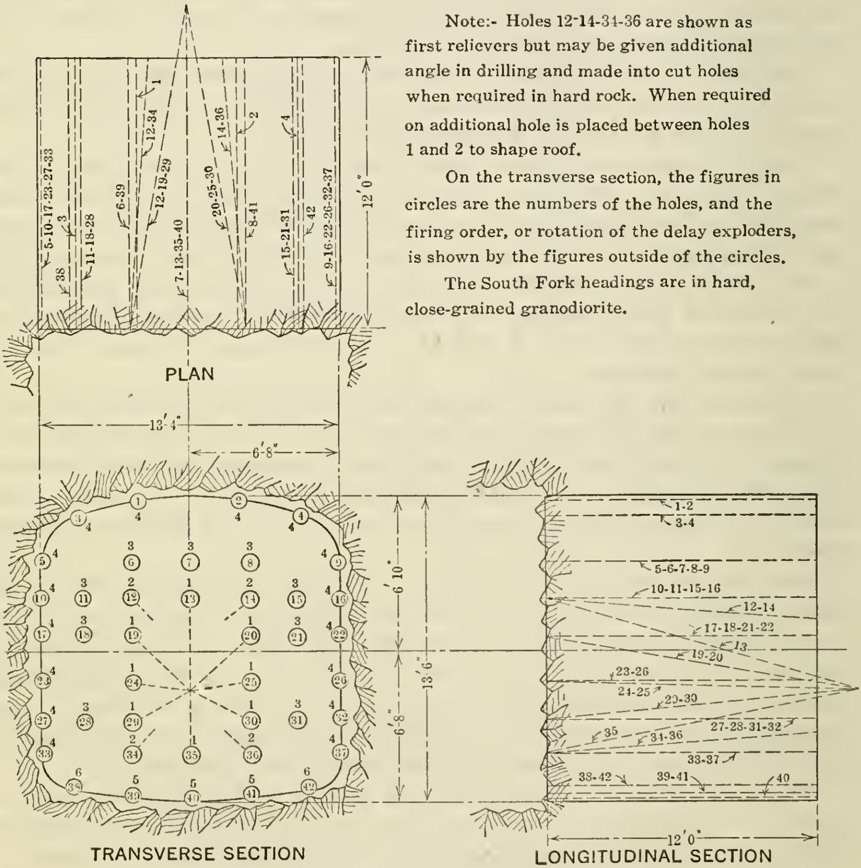
The rate of progress of excavation is from 300 to more than 700 ft. per month, varying according to the formation. The record for one month, 776 ft., was made in August, 1921, in the Priest Heading (west end of Tunnel No. 11). This heading is in altered slate and schist, and is being driven according to the standard section shown in Fig. 8, working three shifts, and drilling 25 holes per round. The excavation to August 31st, 1921, totaled 37 273 ft. for the ten headings in which work is now in progress.

The men are working under a bonus system, under which they receive extra pay in proportion to the excess of the average progress over a predetermined standard rate of progress per shift. The bonus, however, is subject to deduction in case the pay-roll, powder expense, and (in tunnels which are to be lined) the estimated cost of concrete required to fill overbreak, exceed certain fixed amounts per foot of tunnel.

Shafts.—The two shafts are alike in design. Each has three compartments: Two hoisting compartments each 4½ by 4½ ft. inside of timbers, and a manway, 4 by 4½ ft. in which the ladders and pipes are placed. The manway has been found to be too small for convenience. Self-dumping skips with capacities of 32 cu. ft. are used.

Arrangements at Bottom of Shaft No. 1.—At Big Creek, the tunnel level is 575 ft. below the collar of the shaft. The shaft extends 71 ft. farther down,

making the total depth 646 ft. The muck from the headings is dumped into a rock pocket with a capacity of 3 000 cu. ft., about 30 ft. deep. At the bottom of the rock pocket, there are two pneumatic cylinder-operated gates through which the muck can be discharged into either hoisting compartment of the shaft. These gates are operated by an attendant at the level of the skip landing, and the usual time of loading a skip is 15 sec. At the same level is the pumping station, for which the lowest 30 ft. of shaft is the sump.



MAIN AQUEDUCT - MOUNTAIN DIVISION
DRILLING DIAGRAM : SOUTH FORK HEADINGS

FIG. 10.

The neat tunnel section being driven from this shaft is 11 ft. 3 in. wide, outside the lining. At the shaft, it is widened out to 16 ft. for a length of 120 ft., and two or three recesses are also provided, giving space for charging the storage battery locomotives and for storing and repairing locomotives, cars, mucking machines, or other equipment which is too bulky to be hoisted conveniently to the surface.

Summary of Work Completed to the Present Time

The principal achievements on the project thus far include: Purchase of reservoir lands, water rights, rights of way for the Hetch Hetchy Railroad and for the main aqueduct in the Sierra Nevada, and lands for the Groveland Headquarters and Moccasin Creek Power Plant; construction of the Hetch Hetchy Railroad and purchase of rolling stock; construction of the Lake Eleanor Dam; construction of the Lower Cherry Power System, including a 3½-mile aqueduct, 3 000-kva. power plant, and 33½ miles of transmission lines; 8 miles of main aqueduct tunnels have been excavated; at the Hetch Hetchy Dam site, excavation to foundations has been completed and the pouring of concrete has been begun; and the outlet valves for the Hetch Hetchy Dam have been constructed.

The expenditures to the present time total about $14 000 000. The number of employees on the construction work of the entire project averaged about 1 377, during the fall of 1921.

The Engineering Staff of the Hetch Hetchy Development includes the writer who is Chief Engineer, and N. A. Eckart, M. Am. Soc. C. E., Engineer, Hetch Hetchy Project. The City Office staff includes Leslie W. Stocker, M. Am. Soc. C. E., Assistant Engineer; R. P. McIntosh, Hydraulic Engineer; R. J. Wood, Structural Engineer; Paul J. Ost, Electrical Engineer; and, Edwards P. Jones, Mechanical Engineer. On the Construction Staff are: C. R. Rankin, M. Am. Soc. C. E., Construction Engineer, Hetch Hetchy Dam; and, Lloyd T. McAfee, Construction Engineer of the Aqueduct tunnels, and Superintendent of the Hetch Hetchy Railroad.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

SIPHON SPILLWAYS

By G. F. Stickney,* M. Am. Soc. C. E.

To be Presented March 1st, 1922.

Synopsis

This paper relates to the use of the siphon for discharging water and for regulating the water level at a dam, or in a canal. The different types of siphons are described, and the principle of their operation is given. Various siphon spillways that have been built and are in operation in the United States, are described, together with the conditions prevailing at each site, illustrating the uses for which the siphon may be adapted.

The siphon spillway is a device for discharging water at a dam and was introduced in the United States by the writer, on the New York State Barge Canal, thirteen years or more ago. Since the first spillways were constructed, numerous experiments have been made, and the siphon has been improved and developed, so that now it is used for discharging volumes of water far greater than was originally contemplated. The water is discharged through a closed conduit, which makes it possible to utilize the fall at a dam to increase the velocity of flow, and the spillway is put in operation by a slight rise in the water level, above the dam. The action is entirely automatic and priming takes place quickly, so that the full capacity of the spillway is effective at once. The fluctuation of the water surface, above the normal stage, is restricted within narrow limits. The rate of discharge over a dam depends on the depth of water on the crest, increasing as the depth increases, and hence an overfall spillway may not have much discharge capacity until the water surface rises to a considerable height. Such a spillway is not immediately responsive to variations in the stream flow and does not closely control the water level. Properly designed siphons have a wide range of usefulness in hydraulic developments of various kinds.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

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Although siphons were known to the ancients and have been utilized for hundreds of years, their use was confined to small tubes, of an inverted U-form, for conveying liquid over the edge of a vessel and delivering it at a lower level; it is within recent times, only, that the siphonic principle has been applied to conduits of large size and capacity, for discharging water at a dam. The action depends on the difference in pressure at the extremities of the conduit, the flow being toward the lower level and ceasing when the levels coincide, or when air collects at the highest part of the conduit. Water flows, by gravity, from a pool or basin to a lower level, and this flow is produced by a column of water the height of which is equal to the difference in level of the free water surfaces at the inlet and the outlet. In order to pass water over a summit in the siphon, higher than the upper water surface, it is necessary to utilize the air pressure on the water surface. A clear idea of siphonic action may be had if it is understood that the flow is due to the "push" of air on the upper water surface and in no way is due to any "pull" of water in the lower leg. This fact being grasped, it is evident that there is no possibility of increasing the flow through a siphon by prolonging the lower leg below the siphonic limit.

Normal atmospheric pressure at sea level, is 14.7 lb. per sq. in. at 32° Fahr., which is equivalent to the pressure at the foot of a column of water 33.9 ft. high, and is the greatest head that may be utilized for producing siphonic flow. The decrease in atmospheric pressure may be taken as 0.5 lb. for each 1 000 ft. above sea level, hence the siphonic head decreases, approximately, 1 ft. for each 850 ft. of altitude.

Consider a siphon with its inlet and its outlet submerged, as shown in Fig. 1. The water surfaces are represented, by dotted lines, as being raised above their true levels to such heights as would be necessary to give pressures equal to the atmospheric pressure at the ends of the siphon. The water at the inlet, being under pressure, would completely fill the conduit and one can imagine the siphon to be deeply submerged. All that is necessary, to bring about such a condition is to exhaust the air from the siphon, and rapid flow will take place. In order that a siphon may flow continuously, it is necessary that all parts shall lie below the hydraulic grade between the raised upper and lower levels, as shown, since if any part is above such an hydraulic grade, air will accumulate and will cause a back pressure against the water at the inlet that will stop the flow. A siphon that lies well below the hydraulic grade may receive a considerable volume of air without effect, other than to lower the grade which, of course, decreases the discharge. In such case, the air is carried through the siphon, along with the water, and passes out as rapidly as it enters. If, however, more air is admitted than the water can carry, the hydraulic grade drops and the flow ceases. A siphon in operation, and acting under the siphonic head or less, will continue in operation as long as the inlet is submerged sufficient to prevent the entrance of air, whether or not the outlet is submerged. This is due to the water flowing at too high a velocity for air bubbles to rise in the lower leg against the outflow. The problem is thus resolved into the devising of methods for priming the siphon. A siphon that is sealed against the entrance of air, will be primed when

there is sufficient flow through the conduit to absorb and carry out the air entrapped therein. In some siphons it is necessary that the lower leg be sealed by discharging below the lower water surface or by a sealing basin at the end of the leg, whereas others discharge freely and are sealed by a jet of water in the siphon. The inlet of the siphon should be large, in order that the velocity of inflow will be small and thereby reduce the loss of head at entry. The inlet should also be placed well below the water surface, to exclude float-

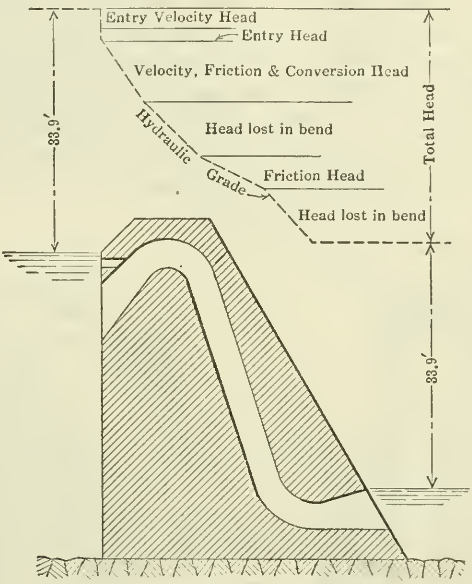

FIG. 1.

ing matter which might clog the conduit. The upper leg should taper, gradually, from the inlet to the minimum section, called the throat at the top of the lower leg. The upper bend, forming the crown, should be made with regular curves of moderate radii. The lower leg may be either vertical or inclined and, ordinarily, should be of uniform area throughout; the latter, however, is not strictly necessary. The outlet should be flared upward, so that air bubbles, rising through the water while the siphon is priming, may be deflected outward. The air vent, extending from the up-stream face of the dam to the crown of the siphon should be located at the normal water level and the crown of the siphon should be just above the normal level so that no water will spill until the water surface rises.

Let a siphon with vertical lower leg be considered, as shown in Fig. 2. The water rises above the air vent, sealing it against the admission of air, and spills through the crown of the siphon, forming a jet at the throat that jumps across the lower leg. This jet makes a diaphragm of water which seals the upper part of the siphon against the entrance of air from below. A certain quantity of air is entrapped above the jet in the crown of the siphon and

this air is absorbed and carried out by the flowing water. It is not necessary to eliminate all the air to induce priming; the removal of a small part is sufficient to start the action. This is due to the fact that the pressure of a confined body of air varies inversely as its volume, and when a part is removed the remainder expands, losing density and pressure in the process. A loss of 3% of the volume of air in the upper part of the siphon will cause the water to rise 1 ft. in the crown and will give a substantial flow through the conduit. As the flow increases, the capacity of the water for absorbing air increases and, in a brief interval of time, sufficient air will be removed to cause the water to fill the crown of the siphon and then the air, in the lower leg will be driven out. Priming takes place quickly, after the flow through the siphon is sufficient to form a diaphragm of sufficient thickness to exclude air, and requires only a few seconds. When the water level, above the spillway, is drawn down so as to unseal the vent, air rushes into the crown of the siphon in such volume that the siphonic action is broken and the flow abruptly ceases.

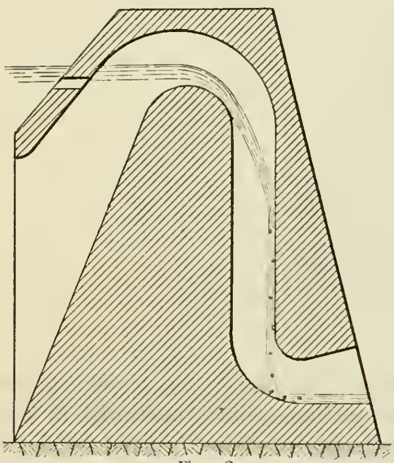

Fig. 2.

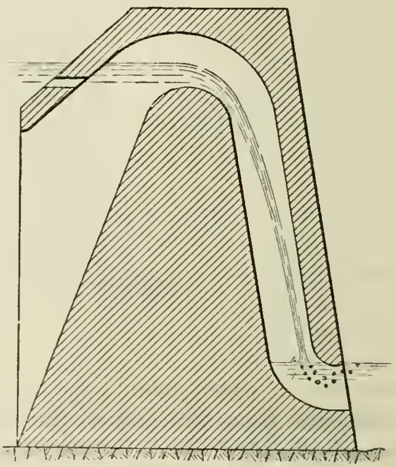

Fig. 3

A siphon with slightly inclined lower leg and a sealing basin at its bottom, is shown in Fig. 3. A rise in the water level above the dam seals the upper end of the siphon and produces a flow of water through the conduit which fills the sealing basin and thus seals the lower end. A jet of water is formed at the crown of the siphon which plunges into the water of the sealing basin, carrying air absorbed from above, and this air is carried outside the conduit, before the bubbles can rise through the water. As in the previous case, priming is a progressive process and is quickly accomplished.

A siphon with the lower leg on a flatter slope and also terminating in a sealing basin, is shown in Fig. 4. In this case, the inclination of the lower leg does not admit of a jet being formed directly, and in the crown, and to the ends and to the far side of the lower leg, recourse is had to an auxiliary chan-

nel where jets are formed, that seal the upper part of the siphon. This causes the upper part of the siphon to prime and produces a flow in the lower leg which carries out the air and primes the lower portion. The sealing basins are provided with small pipes to drain them of water when the siphons are not in operation, so that they will not become clogged with ice in cold weather.

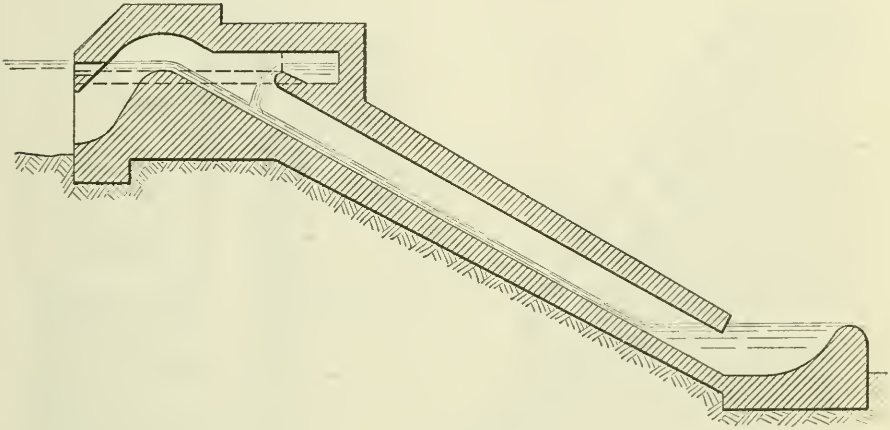

Fig. 4.

Another type of siphon, with inclined lower leg, which does not require a sealing basin, is shown in Fig. 5. In this siphon, a curve is formed in the plane of the back-wall of the lower leg, near the bottom, such that the water flowing through the conduit will be deflected and a jet will be formed that will jump across the leg. This jet makes a diaphragm of water which seals the leg against the entrance of air from below and causes the siphon to prime.

A siphon primed by an auxiliary device is illustrated in Fig. 6. The crown of the main siphon is entirely above the water level, and the lower leg terminates in a sealing basin. Beneath the main siphon is a smaller siphon that has a perforated, horizontal pipe extending along its throat. This pipe is connected with the crown of the main siphon, by branch pipes. The priming siphon, with its crown just above the normal water level, is put in operation by a slight rise in the pond above the spillway and the rapid flow of water over the perforated pipe draws air out of the main siphon. The removal of a small part of the air, entrapped in the big siphon, causes the water to rise and flow through the crown of the latter and this produces a jet that completes the priming. This type of siphon is not as quick-acting, as those previously described, requiring a few minutes to get under way.

All the previously described siphons will prime when there is a slight rise in the water level above the dam, the rise varying from about 3 in. to 1.5 ft., depending on the size and type of the siphon.

Although some types of siphons require submerged outlets, sealing basins are objectionable and should be dispensed with, if possible. When water rises

in a sealing basin, the air entrapped in the siphon is compressed, which may, unless relieved, retard or prevent priming. Further, when priming starts there is a pulsation in the flow, due to air rising inside the siphon from the water of the sealing basin and restoring a part of the volume previously taken away. The sealing basin reduces the effective head somewhat and requires considerable additional masonry, which increases the cost of the structure.

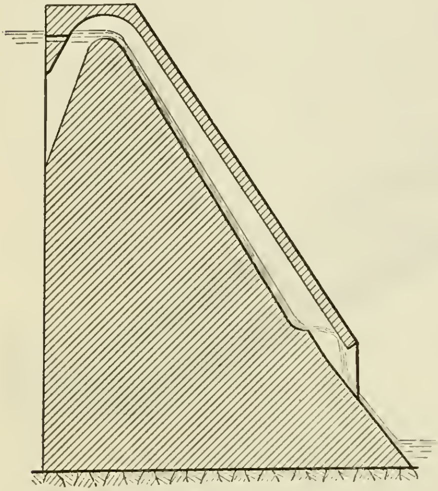

Fig. 5.

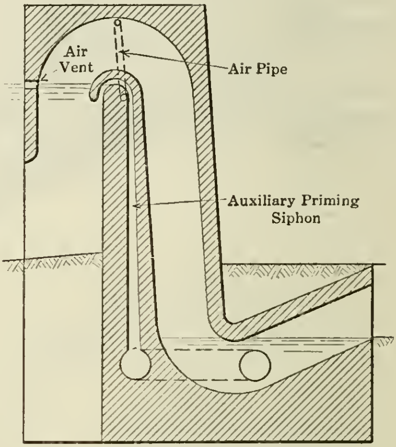

Fig. 6.

During operation, the shell of a siphon is under pressure, the intensity depending on the head. The air pressure tends to collapse the walls of the conduit but this is offset, to some extent, by the fluid pressure within the siphon. In accordance with Bernouilli's theorem, the pressure head plus the velocity head, at any section of a tube under steady flow without friction, is equal to the static head at the section when there is no flow. From this, it follows that the internal pressure, at any point in a siphon, is equal to the pressure at the inlet less the losses in pressure that occur between the inlet and the point in question. The pressure at the inlet is the pressure of the atmosphere on the water surface, equivalent to the hydrostatic pressure from a head of 33.9 ft., plus the head of water over the inlet. The internal pressure at the crown of the siphon is a minimum and may be zero, if the siphon is acting under the maximum siphonic head, and in such case the unbalanced atmospheric pressure will amount to 2 117 lb. per sq. ft. The effective, outside pressure decreases almost to zero at the inlet and at the outlet.

The discharge of a siphon may be expressed by the following formula:

$$Q = C\,a\,\sqrt{2\,g\,H}$$

in which,

Q = discharge, in cubic feet per second.
C = coefficient, varying from 0.6 to 0.8.
a = minimum cross-sectional area, in square feet.

H = head, in feet.
g = acceleration of gravity = 32.16.

The total head acting on a siphon is expended in producing velocity of flow and in overcoming the resistances due to entry, to conversion, to friction, and to bends. This may be expressed by the following formula:

$$H = h_v + h_e + h_c + h_f + h_b$$

in which,

h_v = velocity head.
h_e = entry head.
h_c = conversion head.
h_f = friction head.
h_b = head lost in bends.

It has not been found possible to derive a satisfactory formula for the flow through a siphon, that will take all these factors into account as there is, as far as the writer knows, no formula or experimental data for determining the loss of head at bends in rectangular conduits. From tests made of large siphons, it is found that the loss of head due to bends is large and approximates that due to velocity of flow. Fuller's experiments on the loss of head at bends in pipes indicate that this loss is a minimum for bends with a radius of from 4 to 7 ft., and this possibly also holds good for siphons. Properly designed siphons will have efficiencies of from 60 to 80%, but, for preliminary computations, the former figure should be used.

As the velocity of flow varies as the square root of the head, the discharge of a siphon does not change much for considerable variations in the head. This must be kept in mind and the spillway designed for the maximum flow to be expected. Siphons under low heads are effective, as may be realized by considering that the greatest proportional velocity of flow is due to the first part of the fall.

The first siphon spillway built in the United States is on Wood Creek, adjacent to Lock No. 12, at Whitehall, N. Y. Wood Creek which has a flow varying from 200 to 12 500 cu. ft. per sec., has been canalized, forming a part of the Champlain Canal. The surplus flow, not required for navigation, is used to develop power for a silk mill, on the side of the stream opposite Lock No. 12. The fluctuation of the water surface during the navigation season is limited to 1 ft. above the low-water plane, which is closer regulation than is possible at this site with a fixed dam in the available width of 90 ft. A low dam was built here, with a movable crest of 8 ft., which may be raised above the water surface in time of flood. In order to avoid frequent manipulation of the crest for minor fluctuations in the flow, such as occur from day to day, a siphon spillway was constructed in the forebay of the silk mill. This spillway consists of six siphons each 0.5 ft. high by 8.6 ft. wide, and acting under a minimum head of 13 ft., has a capacity of about 450 cu. ft. per sec. The crown of the siphon is just above the low-water level and the inlet, 2 ft. high by 4.3 ft. wide, is 7 ft. below the water surface. The upper leg converges in section from inlet to throat, the latter being 4.3 sq. ft. in area. The lower leg is vertical and of the same area as the throat, but changes in

section from 0.5 ft. by 8.6 ft. to 2 ft. by 2.2 ft. at the outlet. Three 4 by 12-in. air vents, to the crown of the siphon, pierce the up-stream face of the dam at the low-water level and a fourth vent, of the same size, is located 3 ft. lower. A rise of 0.4 ft. in the water level is sufficient to start the siphons in operation. It was thought that the air vents might possibly become clogged, in which case the flow would not be stopped when the water was drawn down to them. To provide against such a contingency, a 3-in. pipe over the siphons connected with the crown of each and extended through the masonry, where the end was closed by a removable cap. It was believed that by removing the cap sufficient air would be admitted to stop the siphons. A test of this device resulted in failure to stop the siphons and the air admitted had no perceptible effect on their operation. This spillway has been in satisfactory operation since it was built and has never failed to operate during cold weather.

The next spillway is on the summit level of the Champlain Canal, at Lock No. 9, near Smith's Basin, N. Y. This spillway consists of four siphons, each 1 ft. high by 7.75 ft. wide, together with a waste weir, 20 ft. wide, which is provided to pass drift too large to go through the siphons. The capacity of this spillway, when there is a rise of 1 ft. in the water level of the canal, is about 555 cu. ft. per sec., the siphons passing 485 cu. ft. per sec. under a 10.5-ft. head. The siphons are similar in construction to those at Whitehall.

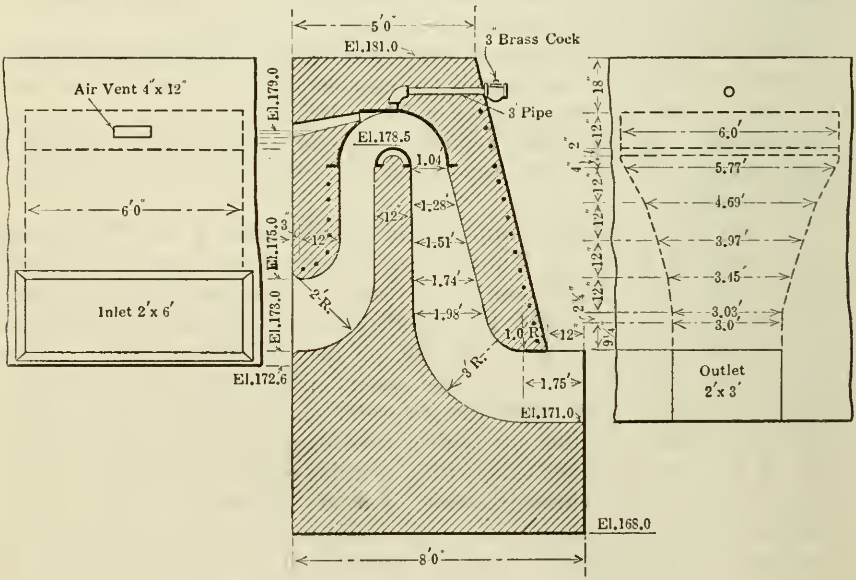

FIG. 7.

The siphon shown in Fig. 7 is on the Glens Falls Feeder which supplies water for the Champlain Canal. This feeder is a navigable channel with a drop of 134 ft. in a distance of 7 miles and extends from the Canal to the Hudson River above Glens Falls. There are 14 locks, either single or in flights,

around which the water is carried in concrete-lined by-passes and at the head of each by-pass is a concrete bulkhead containing four 2 by 3-ft. sluice-gates and a siphon spillway. There are eight of these bulkheads, identical in all particulars, with a single siphon, 1 ft. high by 6 ft. wide, which operates under a head of about 5.7 ft. The crown has a cast-iron lining which was used on account of the difficulty of removing forms from such a small conduit. The crest of the siphon is ½ ft. below the normal water level, so that at all times there is a slight flow through the spillway of about 8 cu. ft. per sec., which is not objectionable since there is a constant feed of water through the by-passes. A rise of 3 in. in the pool level submerges the air vent and the siphon primes immediately. A test was made to determine the discharge and the efficiency of the siphon at combined Locks Nos. 2 and 3. The by-pass is 16 ft. wide by 200 ft. long and has a fall of 12 ft., in four drops of 3 ft. each, with level stretches between. The drops are located 33 ft., 58 ft., 83 ft. and 108 ft., respectively, below the siphon outlet, with a fifth drop of 1 ft. at the end of the by-pass. A weir to measure the discharge was constructed at the lower end of the channel, 192 ft. below the siphon outlet. This weir was made of a 2-in. plank with an ⅛-in. steel plate, machined to a true edge, projecting above the wood, on the up-stream side, and the edge of the plank was beveled on the down-stream side. Vertical planks at each end, with similar steel plates on their inner edges, reduced the length of the weir to 13.93 ft. and its crest was 0.95 ft. above the bottom of the channel. The head on the weir was measured by a bottle gauge in a stilling-box, at the side of the channel, 16 ft. above the weir. The gauge was made of a 1-gal. water bottle, used for a float, with a wooden staff, divided to hundredths of a foot, inserted in the neck of the bottle and held erect by guides on the stilling-box. Baffle-boards were placed in the by-pass above the weir, to check the velocity and to equalize the flow of water across the width of the channel. A second bottle gauge was located at the side of the channel, just above the bulkhead, to measure the head on the siphon. The gauges were read simultaneously, at intervals of 1 min. during the test, and the discharge of the weir was computed by Bazin's formula, $Q = m\,L\,H\,\sqrt{2\,g\,H}$, using the coefficient, m, as determined for a weir 0.98 ft. high, and correcting the length of the weir by Francis' formula, making $L = 13.93 - 0.2\,H$. The results of the tests are shown in Table 1.

The cross-sectional area of the siphon is 6 sq. ft. and the inlet is 12 sq. ft. The head on the siphon was measured from the water surface to the upper tangent point of the outer curve at the siphon outlet, as it was found by reaching into the outlet, while the siphon was running, that the water was not in contact with the concrete below the tangent point and air extended that far up the leg. The velocity head, entry head, and friction head may be computed from the test data and the sum of these, deducted from the total head, gives the loss of head due to the resistance at bends and to conversion in the upper leg, as shown in Table 2.

The siphon primed when the water surface rose 0.1 ft. above the top of the air vent and the siphonic action stopped when the water level was drawn

down to the top of the vent. A 3-in. pipe, closed by a valve, had been provided in the top of the siphon, in order to be able to stop the discharge in case the vent should be clogged, and when the valve was opened, air rushed into the siphon and the flow stopped.

TABLE 1.

Time, A. M.	Depth on weir, in feet.	Weir discharge, in cubic feet per second.	Head on siphon, in feet.	Velocity in siphon, in feet per second.	Efficiency of siphon percentage.
11- 9...........	1.19	68.9	5.64	11.48	60.3
10...........	1.21	70.8	5.66	11.80	61.8
11...........	1.20	69.9	5.67	11.64	61.0
12...........	1.21	70.8	5.70	11.80	61.6
13...........	1.21	70.8	5.72	11.80	61.5
14...........	1.20	69.9	5.74	11.64	60.6
15...........	1.20	69.9	5 75	11.64	60.5
16...........	1.20	69.9	5.77	11.64	60.4
17...........	1.21	70.8	5.75	11.80	61.3
18...........	1.20	69.9	5.63	11.64	61.2
19...........	1.21	70.8	5.58	11.80	62.2
20...........	1.20	69.9	5.50	11.64	61.9
Average....	....	....	....	....	61.19

TABLE 2.

Velocity in siphon, in feet per second.	Head on siphon, in feet.	Velocity head, in feet.	Entry head, in feet.	Friction head, in feet.	Other losses, in feet.
11.48	5.64	2.05	0.26	0.38	2.95
11.80	5.66	2.16	0.27	0.39	3.84
11.64	5.67	2.10	0.26	0.38	2.93
11.80	5.70	2.16	0.27	0.39	2.88
11.80	5.72	2.16	0.27	0.39	2.90
11.64	5.74	2.10	0.26	0.38	3.00
11.64	5.75	2.10	0.26	0.38	3.01
11.64	5.77	2.10	0.26	0 38	3.03
11.80	5.75	2.16	0.27	0.39	2.99
11.64	5.63	2.10	0.26	0.38	2.89
11.80	5.58	2.16	0.27	0.39	2.82
11.64	5.50	2.10	0.26	0.38	2.76

A siphon spillway is utilized at Plant No. 2 of the Tennessee Power Company on the Ocoee River, near Cleveland, Tenn. A timber flume with a capacity of 1 200 cu. ft. per sec. carries water to the plant, at which there is a head of about 250 ft. The flume passes through a small ravine high up on the hillside adjacent to the plant, where a forebay with a siphon spillway was constructed to discharge the flow, in case of a sudden shut-down of the plant. The normal flow line is 1 ft. below the top of the flume and the area of the forebay is so small that the water would overtop the flume in a few seconds if a spillway were not provided. An overflow waste weir was impracticable and it was feared that mechanically operated gates could not be relied on to operate within the limited time available. A siphon spillway, occupying a length of 90 ft., solved the problem, both for rapidity of action and for capacity of discharge. This spillway contains eight siphons, each 1 ft. high

by 8 ft. wide. Half the units act under a head of 18.5 ft. and the other half under a head of 26.5 ft. and give a discharge of nearly 1 600 cu. ft. per sec. The siphons vary only in the length of the lower leg and are as shown in Fig. 8, which illustrates one of the longer siphons. On the completion of the plant, tests were made to determine the maximum rise of the water surface in the flume above the spillway, the speed of priming the siphons when the water rose at various rates, and the discharge capacity of the spillway. To make this test, the flow in the flume was adjusted to supply the turbines of

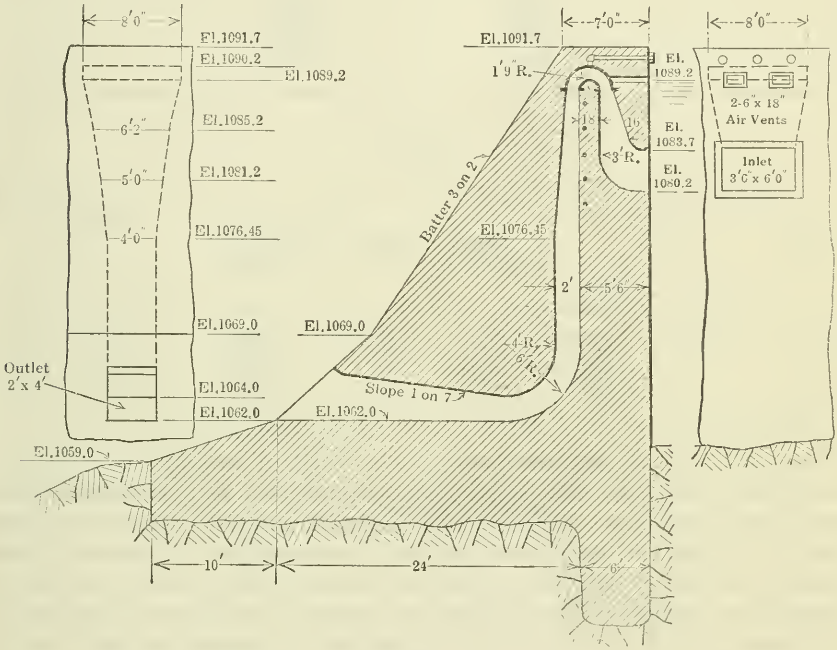

FIG. 8.

the plant and to maintain the water level in front of the spillway at the crest of the siphons (Elevation 1 089.2). By pulling a switch in the plant a predetermined load was thrown off the generators and the turbine governors closed or partly closed the wheel-gates, which caused a rise in the water level in the flume. A staff gauge, reading to hundredths of a foot, was established on the face of the spillway between Siphons Nos. 3 and 4, to give the elevation of the water surface, and time intervals were determined with a stop-watch. Six tests were made, from which the data in Table 3 are taken.

Before the rise began, the water was at practically Elevation 1 089.2 in each case, and the top of the air vent is at Elevation 1 089.45. Since priming could not occur until the air vent was submerged, the lowest elevation at which siphonic action could be established was 1 089.45. Since the discharge through each unit before the siphonic action was established would be small, it may be assumed that the water level rose at a uniform rate during each

test, though this is not strictly true, and the approximate time required to prime the siphons may be computed from Tests Nos. 2, 4, 5, and 6, as shown in Table 4.

TABLE 3.

Test number.	Power thrown off, in kilowatts.	Maximum elevation of water surface, in feet.	Time of rise, in seconds.
1	1 500	1 089.55	....
2	1 700	1 089.55	21
3	3 400	1 089.65	....
4	3 000	1 089.57	17
5	6 000	1 089.75	12
6	9 000	1 089.95	8

TABLE 4.

Test number.	Elevations of water, in feet.		Rise, in feet.	Time in seconds.	Rate of rise, in feet per second.	Time required, in seconds.	
	Low.	High.				To seal.	To prime.
2	1 089.20	1 089.55	0.35	21	0.01667	15.00	6.00
4	"	1 089.57	0.37	17	0.02176	11.49	5.51
5	"	1 089.75	0.55	12	0.04583	5.45	6.55
6	"	1 089.95	0.75	8	0.09375	2.67	5.33

From Table 4, it appears that the time required to prime is probably a constant for any particular siphon and is not affected by the rapidity of the rise in the water level. Large siphons might be expected to require a longer period to prime, but the action is certainly very rapid for the type of siphon installed at Ocoee. The capacity of two siphons, Nos. 5 and 6, acting together, was determined in the following manner. The gates at the head of the flume were adjusted to give a flow of 390 cu. ft. per sec., as determined by a rating curve, and the air vents in Siphons Nos. 5 and 6 were sealed, so that they would continue to operate when the water was drawn below the normal level. The turbine gates were then closed, so that no water was drawn off through the plant and, in consequence, the water in the flume rose, putting all the siphons in operation. The spillway discharge, being much in excess of the flow in the flume, caused a quick lowering of the water level and, when the air vents of the siphons were exposed, all units, except those with sealed vents, ceased to operate. This left Siphons Nos. 5 and 6 in operation, and as they were discharging more water than the flume supplied, the level continued to fall. After the water had been drawn down to Elevation 1 088.7 (0.5 ft. below the crests of the siphons), the time was observed. A second observation, made 7.5 min. later, showed a further drop to Elevation 1 088.4, or a fall of 0.3 ft. in 7.5 min. The average head on the siphons, during this 7.5 min., was 25.55 ft. (measured from the water surface to the center of the outlets) and the siphons discharged the 390 cu. ft. per sec., flowing in the flume, plus a certain volume of water drawn from storage in the flume and the

forebay. The area of the forebay is 10 000 sq. ft. and the area of 300 lin. ft. of flume, beyond the spillway, is 4 260 sq. ft., making a total area of 14 260 sq. ft. The volume of water taken from this area in 7.5 min. was $14\,260 \times 0.3 = 4\,278$ cu. ft., which is equivalent to a flow of 9.5 cu. ft. per sec. In addition, a volume of water was drawn from the flume, between the spillway and the head-gates, which was estimated to be 10 500 cu. ft., and this is equivalent to a flow of 23.3 cu. ft. per sec. for 7.5 min. Thus, the total discharge of the two siphons was about $390 + 9.5 + 23.3 = 422.8$ cu. ft. per sec. The minimum cross-sectional area of the siphons is 8 sq. ft. each, or 16 sq. ft. for the two, hence, the velocityof flow was $\frac{422.8}{16} = 26\,425$ ft. per sec. As the theoretical velocity, under the 25.55-ft. head, is 40.54 ft. per sec., the efficiency of the siphons was $\frac{26.425}{40.54} = 0.652$. Since four of the siphons act under a head of 18.5 ft. and four under a head of 26.5 ft., the total capacity of the spillway is:

$$Q = (0.652 \times 32)\ \sqrt{64.32 \times 18.5} + \sqrt{64.32 \times 26.5} = 1\,581 \text{ cu. ft. per sec.}$$

In this case, the velocity head is 10.85 ft.; the entry head is 0.79 ft., and the friction head is 3.04 ft., leaving a head of 10.87 ft. to overcome the resistances at bends and of conversion in the upper leg of the siphon.

Another spillway, at Rochester, N. Y., was built in the forebay of Plant No. 2 of the Rochester Railway and Light Company, to discharge the water flowing in the head-race whenever a sudden shut-down of the plant occurs. This spillway consists of a single siphon, 3 ft. high by 16 ft. wide, which acts under a head of about 17.5 ft. The lower leg has a uniform cross-sectional area of 48 sq. ft., but changes in section from 3 by 16 ft. at the throat, to 4 by 12 ft. at the outlet, where the siphon connects with a large pipe that carries the water over a cliff, into the Genesee River. A chute, for disposing of ice from the forebay, joins the pipe, just beyond the siphon outlet. This siphon requires from 10 sec. to 5 min. to get under way, depending on how rapidly the water rises, and the fluctuation of the water surface is from 1.5 to 2.0 ft. No accurate determination of the discharge has been made, but it has been observed that a sudden closing of the turbine gates, when the wheels are drawing 1 200 cu. ft. per sec., causes a rapid rise in the forebay water level followed by a quick drop, which indicates that the spillway capacity is considerably in excess of 1 200 cu. ft. per sec. From this, it appears that the siphon has a high efficiency, probably in excess of 75 per cent.

The siphon shown in Fig. 9 illustrates a low-head spillway for regulating the water level in an abandoned section of the Erie Canal, which is used as a storage reservoir by the General Electric Company at Schenectady, N. Y. This spillway consists of three siphons, each 1.75 ft. high by 4 ft. wide. At times of high water in the Mohawk River, the head may be reduced to 4 ft., which will give a discharge of about 200 cu. ft. per sec. The lower leg is inclined backward, so that the priming jet will strike high up on the far wall of the leg and the volume of air entrapped above the diaphragm will be a

minimum. The crests of the siphons are at the normal water level and the air vents are at varying elevations so that they will be sealed successively, when the water rises 0.7 ft., 0.8 ft., and 0.9 ft., respectively. Priming is practically instantaneous in each siphon, as soon as the air vent is sealed. Since this spillway was built, it has been found desirable to reduce the fluctuation of the water level. This has been accomplished by inserting in the air vents, metal tubes which extend downward to the desired level.

A siphon spillway is used in the Alpine Dam, in Lagunitas Creek Canyon, a short distance north of San Francisco, Calif. The dam is a concrete structure curved in plan, of gravity section, and about 100 ft. high, and impounds water for the supply of various municipalities of the Marin Water District. The spillway occupies a width of 64 ft., in the middle portion of the dam, and consists of six siphons, each 3 ft. high by 7.5 ft. wide. The capacity is

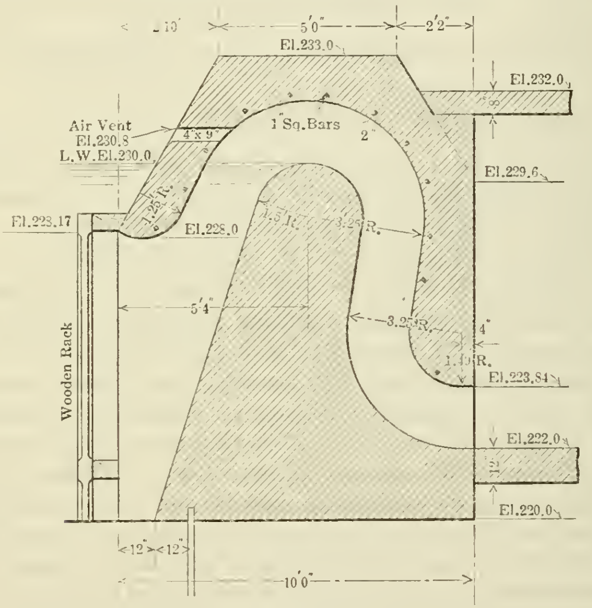

FIG. 9.

somewhat in excess of 4 000 cu. ft. per sec., under a head of 31 ft. The lower leg of the siphon is vertical and is of uniform section, terminating at a bend which deflects the water out to the face of the dam which is formed on a curve of large radius, so that the water will not jump clear of the masonry. Parapet walls confine the outflowing water down the face of the dam, converging to a width of 35 ft. at the bottom, and the discharge is into the natural channel of the stream. The air vents, in the various units, are at slightly different elevations, which makes the siphons prime and cease flowing successively, and thus vary the discharge of the spillway as the reservoir level changes, although a rise of 1 ft. will bring all the siphons into operation. The original plan for this dam contemplated a waste weir at one end, with a waste channel to carry the water. This would have involved heavy rock excavation,

so the siphon spillway was adopted. An overflow waste weir, with a length equal to the siphon spillway, would require a depth of about 6.5 ft. of water on its crest, in order to discharge 4 000 cu. ft. per sec. and to discharge this flow with a depth of 1 ft. on the crest would require a length of about 1 140 ft.

The Hetch Hetchy Dam, across the Tuolumne River, in California, now under construction to provide a water supply for the City of San Francisco, will have a siphon spillway consisting of eighteen siphons. All these siphons will be 4 ft. high, with fourteen units, 10 ft. wide, and four units, 9 ft. 2 in. wide. The inlet of each siphon will be 8 ft. below the water surface and will have an area double that of the lower leg. Since the flow line of the reservoir to be created by the dam will be 3 620 ft. above sea level, the siphonic head will be 29.5 ft. Near the bottom of the lower leg in each siphon, there will be a reverse bend to deflect the flow of water across the conduit, so as to seal the leg. This will cause the siphons to prime when there is a rise of from 1.0 to 1.5 ft. in the reservoir level. The outflowing water, after leaving the siphons, will flow over steps in the face of the dam and drop into the river channel, 180 ft. below. The capacity of the spillway will be about 20 000 cu. ft. per sec.

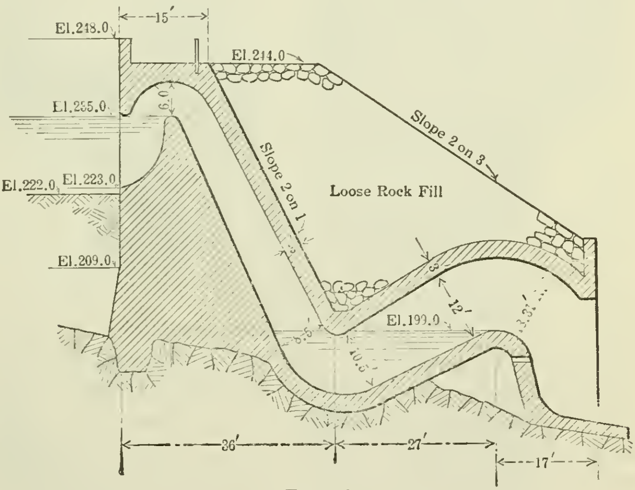

Fig. 10.

The Sweetwater Dam, near San Diego, Calif., has an overflow spillway at one end and a siphon spillway at the other. The siphons are shown in Fig. 10. There are six siphons, each 6 ft. high by 12 ft. wide, acting under a head of 33.5 ft. The inlets are 12 ft. high by 12 ft. wide and the outlets are 12 ft. high by 8.5 ft. wide. The lower legs, which are inclined, are of practically uniform area throughout, varying from 6 by 12 ft. at the throat to 8.5 by 8.5 ft. at the bottom, and terminate in a sealing basin. The discharge capacity of this spillway is estimated to be about 12 000 cu. ft. per sec.

A spillway on the Arizona Canal of the Salt River Project of the U. S. Reclamation Service, near Phœnix, Ariz., consisting of several units, was

built to control the water level at a power plant. The siphons are provided with an air valve, at the top of the crown, to relieve pressure caused by a rise of the water level in the sealing basin which would retard or prevent priming. This spillway acts under a head of 18.5 ft.

Another small siphon, built by the U. S. Reclamation Service, is at the head of the East Park Feed Canal of the Orlando Project, in California. This spillway consists of a single siphon, 1 ft. high by 6 ft. wide, which operates at a rise of 0.2 ft. in the water level and under a head of 17 ft., and has a capacity of about 100 cu. ft. per sec.

The Huntington Lake Siphon Spillway, on Big Creek, a tributary of the San Joaquin River, in California, about 45 miles northeast of Fresno, consists of seven siphons and was built to supplement the discharge over the main

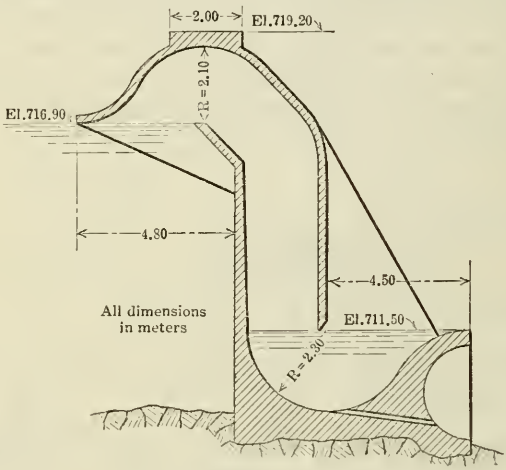

FIG. 11.

dam, which has a crest length of 645 ft. The throat of each siphon is 3.5 ft. high by 12 ft. wide. The inlets are 4 ft. below the normal water level and are 9.25 ft. high by 15.5 ft. wide. The upper legs converge in section to the throat area of 42 sq. ft. The lower legs are of uniform area throughout, but vary in length for the different units. In five siphons, the lower leg is inclined backward and in the other two siphons the leg slopes forward. Sealing basins are provided at the outlets, and each siphon has an 8 by 27-in. air vent, extending from the face of the spillway to the crown. These vents are sealed when the water rises above the crest of the main dam. Siphons Nos. 1, 2, and 3, operate under a head of 12 ft., Nos. 4 and 5, under a head of 15 ft., No. 6, under a head of 18 ft., and No. 7, under a head of 22 ft. The total capacity of the spillway is estimated to be about 5 500 cu. ft. per sec.

There are a number of siphon spillways on the canals of the East Contra Costa Irrigation District, near Brentwood, Calif., which operate under heads of from 17 to 22 ft. The siphons are 3 in. high, and the standard width of units is 6 ft. The spillways consist of several siphons of standard width and a narrower siphon, as may be required to give the desired capacity.

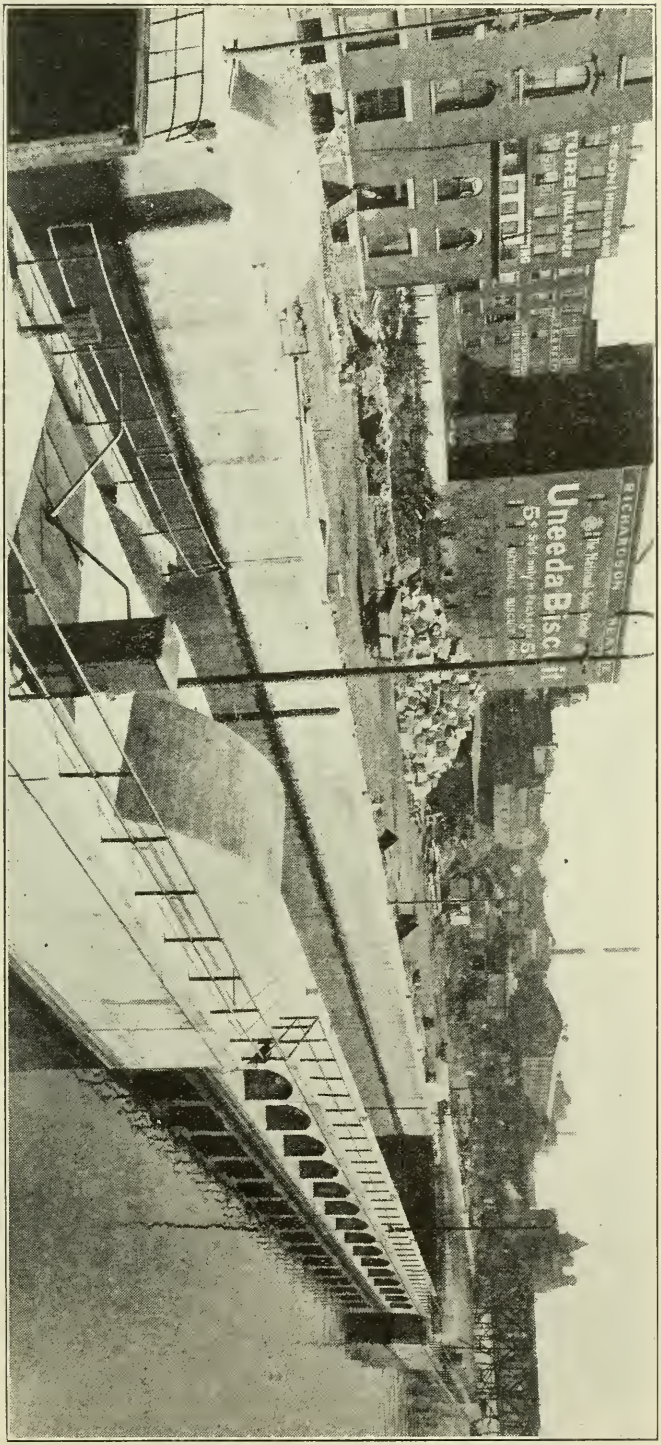

Fig. 12.—View of Siphon Lock, Oswego, N. Y.

The siphon shown in Fig. 6 illustrates a spillway about 3 miles northeast of Ripon, Calif., at the end of the main distributing canal of the South San Joaquin Irrigation District. This spillway consists of two siphons, each 2 ft. high by 3 ft. wide, with a radial, steel flood-gate between the siphons. The main siphons are 0.5 ft. above the normal water level and below these are auxiliary priming siphons, 2 in. high by 3 ft. wide, immediately above the water level. The priming siphons discharge into sealing basins at the outlets of the main siphons. As the operation of this type of spillway has been described, no further explanation is necessary, except to say that a rise of 0.2 ft. in the water level seals the air vent of the main siphon and starts the priming siphon in operation, and that the time required to prime the main siphon is about 5 min. The capacity of the two siphons, under 8.25-ft. head, is about 200 cu. ft. per sec.

A siphon spillway at the Badana Dam, near Genoa, which is typical of a number of such structures in Italy, is shown in Fig. 11. This spillway consists of six siphons, each 6.9 ft. high by 6.2 ft. wide, and operates under a head of 17.7 ft., with capacity of 3 180 cu. ft. per sec.

A siphon, with manually controlled operating device, may be used in place of a sluice-gate, as in Lock No. 8 of the Oswego Canal, at Oswego, N. Y. The lock chamber is filled and emptied through culverts in the side-walls bent up above the upper water surface, forming siphons as shown in Fig. 12. The siphons are put in operation by exhausting the air, entrapped in the conduits, into vacuum tanks, one of which is located in each lock wall, as shown in Fig. 13. These vacuum tanks are connected with the upper pool by 12-in. pipes, with gate-valves to regulate the flow, and are also connected with the lower pool by 20-in. pipes, controlled by gate-valves. A connection between the top of the siphon and the top of the vacuum tank is made with a 4-in. pipe on which are two valves and a pressure-gauge. Valve *A* cuts off the flow in the pipe and Valve *B* serves to admit air to the siphon.

The operation is as follows: The 20-in. outlet valve is closed and the tank is filled with water from the upper pool through the 12-in. pipe; the valve on the 12-in. pipe is then closed and the valve on the 20-in. pipe is opened. The water does not run out of the tank, but is sustained by the atmospheric pressure on the water surface of the lower pool, in which the outlet pipe is submerged. On opening Valve *A* (Valve *B* being closed), the water rushes out of the tank and is replaced by air from the siphon. This air expands to fill the tank, losing density and pressure in the process, so that the atmospheric pressure, on the water surface of the upper pool, causes water to rise and flow through the siphon. This flow of water carries out the remaining air in the conduit, and the full siphonic flow is established. The flow of water through the crown of the siphon then exhausts what air remains in the tank, carrying it down into the culvert, where it is carried along by the water. This air, being compressed by its plunge below the water surface, rises to the top of the culvert and is collected at a recess in the masonry, from which it escapes through a pipe that extends up through the wall to a point above the upper water level, and issues from the pipe with a loud sound. When the air is exhausted from the vacuum tank, it is replaced by water forced up

through the 20-in. pipe by the atmospheric pressure on the surface of the lower pool. As soon as the tank is completely filled with water, Valve A is closed. The siphon continues in operation until the lock-chamber is filled or emptied,

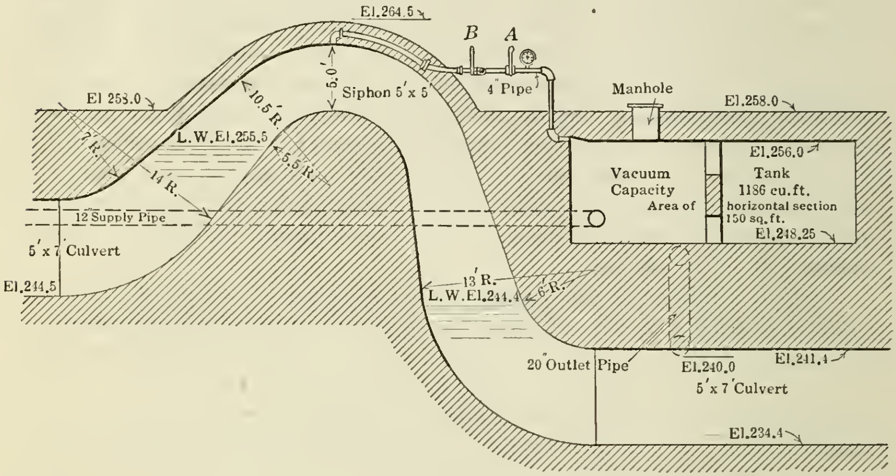

Fig. 13.

depending on whether the upper or the lower unit is being used, and when the flow ceases Valve B is opened to admit air to the siphon. The siphons are 5 by 5 ft. in cross-section at the throat, and the normal lift of the lock is 11.1 ft. The lock-chamber is filled in 4.5 to 5 min. and is emptied in 5.5 to 6 min., the difference being due to the location of the vacuum tanks at the head of the lock, near the upper siphons. With daily lockages, it is not necessary to fill the vacuum tank with water from the upper pool, except for the initial filling at the beginning of the season, the operation of the siphon, from time to time, being sufficient to keep the tank filled.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

THE NATIONAL HOUSING PROBLEM*

A SYMPOSIUM

By Messrs. Lawson Purdy, John M. Gries, Joseph C. Wagner, B. Antrim Haldeman, Charles M. Reppert, H. Malcolm Pirnie, W. L. Stevenson, Allan Robinson, Edward M. Bassett, William H. Ham, and John Ihlder.

With Discussion by Eugene W. Stern, T. Kennard Thomson, Nelson P. Lewis, John Ihlder, Henry H. Curran, Edward S. Rankin, and Benjamin A. Howes.

*Presented at the meetings of January 4th and 5th, 1922.

BROAD ECONOMIC PHASES OF THE HOUSING PROBLEM

By Lawson Purdy,* Esq.

It is generally recognized in the City of New York, and it is not different in most cities of the United States, that the poorest paid laborers must live in second-class houses; that it is impossible from an economic point of view under existing conditions to build houses for those persons who receive the lowest wage scale. It is not a particularly bad thing to live in a second-class house; the speaker has never lived in any other. In New York, particularly in the Borough of Manhattan, it is not desirable to live in a second-class tenement house, but many of the single family houses, built 25 to 40 years ago, are better than the single-family houses built to-day.

The speaker has seen houses in Europe that he would like to live in, that had been built for about 200 years. It all depends on how the house was built, whether it was built for one family or for many, how it was planned, whether it is a pleasant house in which to live, regardless of when it was built.

A great many people in New York, which is probably true of all cities, are eager to reduce the cost of building by crowding too much building on the land; and one hears constantly that the cost of housing and rents are increased by regulation designed to protect tenants in giving them a moderate amount of light and air, and adequate protection against fire. Whenever the speaker goes from New York to Boston, he wonders why insurance losses are not greater than they are. They are greater in the United States than in any other country of the world. Very likely most of the buildings deserve to be burned. If buildings were planned so that they would not burn, and so that people would have light and air, economic conditions would be better.

Some are doubtless familiar with conditions on the lower East Side of the Borough of Manhattan. More than 20 years ago the land was covered with tenement houses, under the law, to 70% of its area, except on corners where 90% or more was covered; but the law was not strictly administered and, often, buildings covered more than the law allowed. The least possible of light and air was left for tenants; the greatest number of people possible were crowded on an acre of ground; and the land on which such tenements were built in the lower East Side was once worth \$1 000 a front foot for lots 100 ft. deep; that is, \$10 per sq. ft., for land housing the poorest class of people. All that was accomplished to increase housing, by allowing that sort of thing, was that the land rose in value because it was earning such an enormous return from the poorest people. In those days, such tenements rented for not more than \$5 per room per month. The landlord did nothing for the tenants except furnish the house and cold water; the conveniences were next to nothing in the old tenements.

To-day, there are men solemnly saying, and explaining that they say it as the result of long experience, that because the regulations for some such houses have been improved, the cost of human habitation has been increased in the City of New York. The speaker does not for a moment believe it.

* Secy. and Gen. Director, The Charity Organization Soc., New York City.

If it is true of the Borough of Manhattan, that no gain is made in reducing the cost of living by crowding people so densely together, by so much the more is it true of the remainder of the City of New York and of every other city of the United States. The principle is the same as that the addition of park space and open areas does not increase the cost.

Sometimes it is contended, by persons who seek the greatest return for themselves and pretend to seek the welfare of their neighbors, that government costs more and money is lost by exempting certain quasi-public institutions; it is claimed they take too much space. This was claimed in regard to the area south of Grace Church on Broadway—one of the near beauty spots of the city. The people who worship in that church had the public spirit to buy the land south of it, clear away the old buildings, and make a little open space there; and some would tax it. It is a blessing to all the surrounding territory, and all that it does is to move the business area just a few inches farther north. When open spaces are left, the population merely moves a little farther out from the most congested center. So it is with respect to regulation for light and air for human habitation. If, instead of crowding 700 people to the acre, as is done in spots on this Island, only 12 families were allowed to the acre, there would be just a little more spreading. There would be more value in the city, of lands and buildings, but that land value would not be concentrated in a few spots, to the advantage of those persons who happened to own those spots originally and to hold them. That would be the only disadvantage.

It may be truthfully said, extraordinary as it may seem, that the death rate is exceedingly low in some of these East Side blocks where the population is most congested. The reason is that in the last 20 years millions have been spent to undo the damage of congestion. The housing regulations have improved conditions; old backyard privies have been done away with; something like decent sanitary conveniences have been installed. The Health Department, which has spent millions every year, has improved the milk supply. In many ways the health of people has been conserved in spite of the conditions in which they live; and these congested centers of the Borough of Manhattan may well be compared with what looks like the attractive characteristics of mid-west cities. If, however, one examines a survey of some of these mid-west cities it will be found that they lack a water supply; they draw their water from neighborhood wells. Sewers are lacking, and the sewage is allowed to go where each householder pleases to put it, and his water is drawn from a well on the same territory. The marvel is that they live at all. The speaker would rather live in a section which has 700 people to the acre than take his chances in one of those cities.

That, however, is not the condition desired. There should be decent housing, for housing comprises all the amenities of life. It means an adequate supply of pure water; it means proper sewers; it means that in every city no house should be permitted, which does not have a water supply, which does not stand on a street with a sewer in front of it, into which the refuse of the house must be carried. New York has gone so far, and it is farther than

in many places, that multi-family houses are not permitted unless they are connected with an adequate sewer. A great deal more might be done. That ought to be the rule throughout the United States; and the time must come in the not distant future, when no longer will any State permit its streams to be polluted with sewage. The time must come when everywhere sewage will be disposed of in such fashion that it will not pollute the waters and will not be a menace to the health of the community.

What can be done in the near future to improve housing everywhere? First, there must be the regulation, mentioned, that every house in a city must be sewered, and served with water. Next, every house must be safe against fire. If wooden buildings are permitted, they must only be permitted when placed at an adequate distance from their neighbors. It is very common for the distance between houses to be no more than 10 ft.; and sometimes three-deck wooden tenement houses are seen—one can see them on the New Haven Railroad all the way from New York to Boston—that appear to stand no farther apart than 6 ft.

The speaker doubts very much whether two or more families should be allowed to live in a wooden building; but if they are, the building should be far enough from every neighbor so that there is no reasonable opportunity for fire to travel from one building to the other. Every building in which more than one family lives should be protected against the danger of loss of life by fire so that people can get out in safety if the stairs are burned. The tenement house population in the City of New York has been so far protected that since the enactment of the Tenement House Law of 1901, which is due largely to the efforts of Mr. Laurence Veiller, that not one person has lost his life by the burning of such buildings.

One might say that every week, people lose their lives in tenement houses which were constructed under the law as it was prior to 1901, and many people lose their lives by fire, here and in other cities, in boarding and lodging houses. A real estate man of the speaker's acquaintance, who has had long experience, states that he has arrived at the conclusion that no building erected for one purpose should ever be permitted to be turned to any other purpose; and, in particular, no building erected for a certain kind of human occupancy should ever be permitted to be altered or changed for any other form of human occupancy, and the speaker thinks he is right.

There are many old single-family houses in this city which, if the law did not stand in the way, could be changed for the occupancy of many families. These buildings are a great menace to human life, both from fire and because of inadequate light and air. The houses were not planned for two families on every floor. They were planned for one family to occupy the whole house, and for one family it might be a fairly good house, although even then it was not safe in case of fire. It was much safer for one family, however, than it would be for several families, because there would not be so many people, and, presumably, they would be concerned about each other's safety, whereas with a lodging house in a great city, no one cares about any one but himself, and so many people are burned in lodging houses every

year. Lodging houses should be regulated by careful legislation, and no lodging house or boarding house should be of such character that the inhabitants are not as safe from fire as they are in the new law tenement house; and they should be provided with an adequate sanitary system and adequate light and air.

All this is within the reach of the law as to buildings hereafter to be erected. As to the old ones, there is comparatively little that is politically practicable to do. The apparent economic loss of burning them down would be great. There is a large part of many cities the destruction of which would be a great blessing if the people were not burned also.

There is now the power to zone cities; although the old densely settled parts of the cities cannot be improved very much, different regulations for the outlying territory can be had that it will be so built up that practically no house will be more than two rooms deep; so that every window shall open to the outer air on the street, or on a wider space at the rear than toward the front.

These buildings can be erected at low cost, lower than the older form of building, because the building itself can be erected in a more economical way, if it is properly planned; and when the first occupants of those new buildings have moved into better quarters, and the lower paid wage earners take possession, they can have decent houses in which to live, because they were planned rightly in the beginning. A well planned, well constructed house, 100 years old, may be better in which to live than a poorly planned house that was built yesterday. It is not intended that an old house which has been ill kept should be regarded with favor, or so constructed as to lend itself to be permeated with vermin and dirt.

Certain classes of buildings become unfit for human habitation before they have been occupied for more than two or three years. The rays of the sun are a great disinfectant, in two ways. Sunlight is believed to kill evil germs; and it is a great deal easier to keep a place clean which is bright and light than a place that is dark. With plenty of sunlight there will be more cleanliness in the old, dark houses. If some of you who come from distant places, go back with the thought that hereafter buildings should be planned so as to be healthful habitations as long as they endure and are properly cared for, and that you shall never again have buildings erected that are dangerous to life, health, and morals, you will have accomplished a great deal. Bad buildings bring bad morals and good buildings bring better morals and a better people.

HOUSING: BROAD ECONOMIC ASPECTS

By John M. Gries,* Esq.

In making a survey of the housing situation in the United States, it is necessary to consider present conditions, some of the causes of these conditions, and how they may be improved.

There is a general housing shortage, due to the events of the last five years, and the rate of new construction is now increasing—that much is generally known.

What, however, is the relation of the shortage to the present inventory, what are those who need homes doing to obtain them, and what is being done to meet the demand? And what provision is being made for the future? A survey of such general facts as are obtainable is not discouraging, although there should be greater conscious efforts to plan for future needs.

The houses of the United States are so widely scattered and vary so greatly in different sections, that they are rarely thought of as a whole, and their aggregate value is not often computed. An inventory, based on census figures, is the only one which can be made and, incomplete as it is, it is the only guide to the vast wealth invested in the houses of this country.

Inventory of Dwellings.—According to the Census of 1920, there are 20 697 204 dwellings in the United States. There are no reliable figures either as to cost or replacement value of these houses, but an enormous amount of the nation's wealth is in its dwellings. If the average value per dwelling is $2 000, the total value of all dwellings would be $41 394 408 000; or if the average value is $3 000, the total value would be $62 091 612 000.

Kind of Houses.—What kind of houses are these? The number includes apartment houses, tenements, all kinds of multi-family houses, single-family houses, sod houses, freight cars, and canal boats if inhabited. Some of these houses cost more than $1 000 000, others only a few hundred dollars. Many are unfit for habitation, but still continue to be occupied.

They are constructed of various materials, stone, brick, brick veneer, stucco, tile, concrete, and wood. Few people have any idea of the ratio that the number of frame houses bears to the total. They judge largely by their own city, and answer 90% brick, or 90% frame, depending on the local conditions. Judging from estimates obtained from real estate boards, officers of building and loan associations, engineers, city officials, and others, more than 75% of all dwellings in the United States are frame.

Judging by the statistics appearing in the press, it would seem that nearly all the houses are in the cities. For example, the building permits issued monthly and widely disseminated cover only the larger cities. Contracts awarded deal largely with the cities as far as residences are concerned. The work of both the engineer and the architect, as it relates to residential building, is largely confined to the cities. In fact, nearly every group largely eliminates rural dwellings from consideration, except the mail-order houses,

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and they probably know more about rural construction than they do about city building.

According to the Census of 1920, the number of urban dwellings was 9 484 552, and the number of rural dwellings, 11 212 652. This means that 54.2% of all dwellings are rural, and 45.8% urban. Although there are more rural dwellings than urban, there are more urban families. There are 12 803 017 urban families and 11 548 659 rural families.

The housing problem has never been considered nationally. How many of the big contractors think of the housing needs, five or ten years hence? Have they considered the construction needed, the annual maintenance, and the possible economies? No, houses are not thought of nationally as one does of the United States Navy, for instance. The authorities carefully consider the needs of the Navy for ten and twenty years in the future. Even the layman thinks about the cost of maintenance. With houses, we fail to get any balance until conditions are such as to force us to act.

Need for More Homes.—As a going concern, the nation needs more homes, and during the last five years comparatively little has been done to increase the number. During the last ten years, the new buildings erected have not kept pace with the increase in population. Conditions have become worse, crowding has increased, and the cost of shelter has advanced materially. During the World War, the building of homes practically ceased, resulting in a shortage of dwellings, approximating at present, a million homes. Although people adjusted themselves temporarily to the crowded conditions, and some may accept them as normal, many will become more and more discontented. The effects will be shown in health and morals. There is much evidence of crowding in some of the large cities. A large number of single-family houses have been converted into two-family houses, and other large houses converted into tenements. Warehouses have also been changed into tenements. The one-family house cannot survive in a neighborhood in which the multi-family house has gained a foothold.

The situation will be met by the building of poorly designed houses of cheap construction, unless the cost of building is reduced materially from what it was in 1920. To build more houses, and better houses at lower cost, is what must be done, and to do this means that waste must be eliminated.

Physical Conditions of the Property.—The maintenance of residential property is most unsatisfactory. Thousands of houses are allowed to deteriorate. In some cases the neglect is deliberate, whereas in others the occupant or owner does not feel financially able to make the necessary improvements.

Too often he has been sold a "white elephant". He has been induced to buy beyond his ability to pay. Houses are often without adequate fire protection, with the resulting loss of many thousands. Hundreds of thousands of houses in the cities have become antiquated. They are being milked or bled dry, and allowed to deteriorate, to go into the discard, when more capital should be invested in them to keep them modern. Of course, there are also many houses which should have been torn down long ago.

Annual Building Necessary.—The number of families which should be provided with houses each year amounts to probably more than 300 000, and

considering the destruction of houses at about 80 000 each year, there is an annual need for nearly 400 000, but during the last five or six years the shortage has grown until now at least 1 000 000 homes are needed.

Whether it is a canal boat, or a sod house, every family wants a house of some kind in which to live. It is probably more essential than a hat or a pair of shoes. Every one does not want the same kind of house, and the choice is or should be guided largely by income.

What Kind of Houses Are in Demand.—No careful market analysis has been made to determine the number of houses needed by the different income groups. Little attention has been given to the income of the non-home owner. It has been assumed that he will continue to occupy the cast-off houses of the better paid. To determine the kind of houses wanted, incomes must be studied. Judging by income tax figures, the number of persons receiving an income between $1 000 and $2 000 makes up the largest single group, and that those receiving an annual income between $3 000 and $4 000 is much smaller, and so on up. This means that the market for small houses will be tremendously increased when such houses can be bought by those receiving an income between $1 500 and $2 000.

Meaning of More and Better Houses.—More and better houses mean more business, more happy families, better and more dependable citizens. Although better houses are most desirable, they cannot be bought and paid for in large numbers unless the cost is reduced.

Costs Must Be Reduced.—The houses of the nation represent an investment of billions of dollars. They are built extravagantly and scrapped recklessly.

What can be done to maintain property, to keep it in repair, to modernize it so that the maximum value can be secured out of the investment? Although some houses should have been scrapped earlier, thousands of houses are razed or scrapped long before the initial investment justified their destruction. The annual depreciation charge is too great. The waste must be taken out of the building industry, a way must be found to modernize old houses, and they must be protected by proper zoning ordinances.

Home Ownership.—Since home ownership is admitted to be of the greatest economic value to a community or nation it must be made possible for the man of average income to buy and pay for a home. At present costs, thousands of those who would like to own a home find it impossible to buy. Of the 24 351 682 homes, 12 943 604 are rented; 10 866 960 are owned by the occupants; and the tenure is unknown of 541 118. Out of the homes that are owned, 6 522 119 or 26.8% of the total are owned free of encumbrance; 4 059 593 are encumbered; 285 248 are unknown as to encumbrance. These figures show clearly that there is much room for an increase of home ownership.

"Own your own home" is a popular slogan for it has an appeal to every family living in a rented house. However, it is poor policy to induce families to buy homes for which they are unable to pay. A home ownership campaign, that merely induces a man of small income to buy a home beyond his ability to pay, is one that deserves public condemnation. The owner soon loses his

small cash deposit, and is compelled to start over again. The home ownership campaign that is really worth while is one that makes it possible for the man not only to acquire title, but to make his payments regularly. It means that every effort is made to reduce the cost of building, and to protect his property after he has bought it.

The percentage of those owning their homes varies widely in different cities. In New York City only 12.1% of the families owned their homes in 1900, and 12.7% in 1920. New York shows the lowest percentage of home ownership of all American cities.

Some cities have shown a marked increase in home ownership during the last 20 years. For example, the percentage of home ownership in Baltimore, Md., increased from 27.9% in 1900 to 46.3% in 1920. Other cities showing considerable increase in home ownership during the twenty years are: Philadelphia, Pa., increasing from 22.1% to 39.5%; Omaha, Nebr., increasing from 27.7% to 48.4%; and Des Moines, Iowa, from 38.5% to 51.1%.

Some cities, however, show a decline, for example, Cambridge, Mass., shows a decline in the percentage of home ownership from 21.2% in 1900 to 17.6% in 1920; Springfield, Mass., from 33.3% in 1900 to 27.9% in 1920; and Los Angeles, Calif., from 44.1% in 1900 to 34.7% in 1920.

Zoning.—Those who would encourage home ownership should also take an active interest in seeing that property is protected. Many cities do not provide adequate zoning ordinances. The loss in property value is an economic loss running into the millions, a direct result of the failure to zone properly. Such losses can only be remedied by the action of society. There may be some ill-gotten gain accruing to some individuals by destroying property values in one section and thus forcing the people to move into another, but this is an economic loss to society, because good houses must be scrapped prematurely.

Not many years ago complaint was almost universal that there was enormous waste in municipal government, that the conditions in some American cities were intolerable, and that action of some kind must be taken. Organizations were created, committees were appointed, newspapers and magazines were founded, and pamphlets in great numbers were issued in an effort to bring about better municipal government. The undertaking has been tremendous, and the task is not yet done, but the improvement in spots has been encouraging.

Although more than a billion dollars are spent annually in city governments, even more money is spent in construction. The amount spent for building and construction is greater than that spent for municipal government. As no individual could possibly reform the extravagance of governments, so no individual or single group can eliminate the unnecessary waste in building. To bring about the desired reforms in the construction industry, the joint efforts of all groups is needed. The architect, engineer, contractor, sub-contractor, laborer, real estate dealer, building material dealer and producer, financier, and the public must all aid in bringing about better conditions. The cost of houses must be reduced through the elimination of waste in the entire construction industry.

What does it mean to build a large number of houses? Although the prime object is to provide shelter, many more are interested than the ones who are to occupy the houses. To indicate those who are interested, gives some idea of the breadth of the construction industry. To build the houses requires that the operations be financed. This calls for the banker, the building and loan association, second mortgage companies, and others, such as the insurance companies and the private lenders. We not only employ carpenters, bricklayers, masons, etc., in the building trades, but it means increased employment in all the plants supplying materials for construction. It not only means that the sales of producers are increased, but the sales of wholesalers and retailers as well.

This, however, is not all, for the building of new houses brings about greater activity in the furniture factories, stove foundries, carpet and rug factories, and in plants making draperies, curtains, kitchen utensils, picture mouldings, and all house furnishings.

The building of more homes means more taxable property. It does not call for more tax exempt bonds, nor, with few exceptions, is there tax exempt property as a product.

There should be a revival in building during 1922, but conditions do not warrant an enormous building program. A little more house-cleaning is needed in spots, and more efficient production with lower costs before great activity in building will prove of great economic value. Although law will do some good, the industry can do much more by a joint effort to remove restrictions, and to eliminate the waste. In some cities conditions are favorable for building, whereas, in others, local community action is necessary before building should start.

Waste in Construction Industry.—Attempts have been made to estimate the waste in the construction industry. That it is enormous is evident, and admitted by all who are acquainted with the industry. Certain practices, abuses, and customs must be changed before much can be expected. No single group is entirely at fault, nor can any single group bring about a reform. The engineer, architect, contractor, laborer, and building material dealer all know of unnecessary or expensive practices, but they alone can do but little. These groups, and also the public, must act.

Waste occurs in many places. To enumerate a few will make it evident that something should be done. Some of these places are:

1.—Lack of standardization.

2.—Absence of factory methods in construction.

3.—Unnecessary restrictions in building codes.

4.—Excessive capital required due to seasonal work.

5.—Jurisdictional disputes.

6.—Failure to schedule work.

7.—Trade agreements.

8.—Corrupt practices.

9.—High discount rates for second mortgage money.

10.—Failure to plan and zone a city properly.

Lack of Standardization.—If there is to be quantity production, there must be a greater standardization of parts in small houses. Why should there be more than four hundred different sizes and styles of window sash? Why so many different sizes and shapes of door hinges? Why so many different kinds of pipe? As long as the public insists on so many varieties, the manufacturers must be equipped to produce them. This means more capital invested in plant, more fixed charges, less production for stock. It also means that the wholesaler and the retailer must carry a heavier stock. This carrying charge must be passed on to the home owner or the renter. Some may say that such standardization will destroy initiative and individuality. The large and expensive house is still the object for all the initiative and individuality necessary.

As a rule, much more work is done on the job than is economical. Materials are poorly routed, often not at all. The carpenter often carries a piece of studding many feet, cuts it to length, and puts it into place, while in more efficiently managed places all stock is brought to him by common labor.

Unnecessary Restrictions in Building Codes.—Those who are truly interested in better housing do not want to see a general breaking down of the building codes, but they are interested in the elimination of the absurd restrictions and the unnecessary requirements. Two examples are sufficient to show the need of changes in some of the codes. In one city, an 8-in. brick wall is considered safe for a two-story house, and in a near-by city the code requires that the wall for such houses shall be 16 in. thick. In some cities, the floor load in such houses must be at least 40 lb. per sq. ft., and, in some, it must be 100 lb. per sq. ft. If an 8-in. wall is enough, why require one of 16-in.? If 40 lb. per sq. ft. is safe in some cities, why not in all cities?

Excessive Capital Required Due to Seasonal Character of Work.—Building is carried on actively for only a few months. People insist on doing their repair work in the summer. The seasonal character of the industry makes it necessary for many to make their income during a few months. Labor must earn enough during the few months to live on for twelve months. The contractor and building material dealer must do likewise. The contractor must be equipped to take care of the peak, even though part of his equipment lies idle for eight months of the year. Every establishment dependent on the construction industry, having a seasonal business, must maintain an investment necessary to take care of the peak load. Millions are invested to take care of the peak, and the home owner and renter pay for the excessive capital required, because they insist on doing all their work during the busy season. In most sections and during most years, building could just as well be fairly active during ten months of the year instead of five or six.

Jurisdictional Disputes.—Stoppage of work due to jurisdictional disputes has resulted in loss. At the Unemployment Conference called by President Harding, a resolution was adopted declaring that "stoppage of work from jurisdictional controversies in the construction industry should be permanently abandoned as detrimental to the public welfare."

Failure to Schedule Work.—Such failure might be interpreted as "waste in small scale production". A more or less efficient building practice has been

developed in the construction of large office buildings, large apartment houses, and typical factory buildings. In the erection of a large steel factory building, for example, the different pieces are marked, and the work is scheduled so that both labor and materials are on hand when and where wanted. The greater efficiency seems to prevail in the rougher types of factory buildings, decreasing as the type of building becomes higher. In complex and elaborately finished structures the scheduling has not been so well worked out. There is little sign of efficient management in the building of small houses, except where they are built in large numbers. It is claimed that of the small houses a very high percentage is built by contractors who build less than ten houses annually. These contractors as a rule do not schedule their work well, nor does such building lend itself to efficient scheduling. They are uncertain of the arrival of materials; they are uncertain about the number of laborers they will have on a given date; nor do they know the exact order of work on the different jobs they have under way.

The designs of the buildings may also be different. Part of the houses may be on one side of the city, and part on another, and they may not be built of like materials. Building under such conditions makes it impossible to buy to advantage.

Cost of Financing Building.—During the last two years, the cost of financing building has been high. Besides a high interest rate, bonuses and commissions were common. Second mortgage notes are often discounted at from 10 to 20 per cent. Note shavers and second mortgage companies often discount paper 20 per cent. This may seem excessive, but it must be remembered that with the fall in building costs, the second mortgage was more than ordinarily hazardous. If a small cash payment was required, it could easily happen that the second mortgage was not covered. Although the party who discounted the notes may have been justified, it is, nevertheless, a fact that such charges make the cost of houses entirely too high. The shortage of real estate mortgage money is in part due to the great increase in tax exempt securities.

Failure to Plan and Zone a City Properly.—The taxpayers spend millions annually, because cities are poorly planned and little or no attention is paid to zoning. The widening and cutting through of new streets alone costs enormous amounts. Much of this expense could have been saved had the most elementary rules of city planning been followed.

Thus far, this discussion has pointed out mainly the weak points in the construction industry. The conditions are not as bad as one might assume from the points considered, for the various groups interested in building are trying to bring about better conditions. They are in earnest, too, and are doing good work. What they need is encouragement and help. The public should do its part.

Building Codes.—One encouraging sign is the keen interest shown in the adoption of better building codes. In the summer of 1921, Secretary Hoover appointed an Advisory Committee on Building Codes, and later a Sub-Committee on Plumbing. These two committees are at work, and the co-operation which has been given them, shows a wide interest in many cities. The co-

operation that the Committees have received from associations, engineers, architects, contractors, city officials, and others, has been excellent.

Zoning and City Planning.—The interest in zoning is especially active at this time. More than 50 cities have passed zoning ordinances, and 93 cities have zoning ordinances in preparation. Secretary Hoover appointed an Advisory Committee on Zoning in the summer of 1921, which is actively at work. The work of this Committee will be of great value in furthering sane zoning ordinances to protect the home owner's equity in his property.

Architects' Interest in Small Houses.—In the past architects have taken little interest in the small house of 4, 5, or 6 rooms. The Small House Service Bureau has been organized, and endorsed by the American Institute of Architects. The organization now furnishes house plans, quantity surveys or bills of materials, and architectural service for a small fee to the builder of houses of six rooms and less. Standard sizes are used in the houses.

During the last few months the interest in the elimination of varieties has increased noticeably among producers of building materials. The initiative often comes from the producers, and others often express a willingness to co-operate.

One of the most important facts is that the architect, contractor, building material producer and distributor, and labor are conscious that they are a part of a big industry and have some interests in common. As evidence of this consciousness one will find such an organization as the National Federation of Construction Industries, which includes many associations, contractors, engineers, producers of brick, tile, lumber, hardware, also retailers and wholesalers. Its aims are to make the construction industries serve the public more efficiently as a whole and by a process of education to make them harmonize their aims.

The National Congress of the Building and Construction Industry with its local chapters aims to accomplish work along the same lines. It includes all groups interested in construction. Local conferences have been strongly urged by Secretary Hoover since April, 1921.

Chambers of commerce, or groups organized for the purpose, have instituted community conferences in which an attempt was made to secure the co-operation of all interested groups in the city. All these are concerned in eliminating bad practices, in seeing that no group absorbs the savings effected, for they know that only through a reduction in costs can building become active. They realize that volume of business is best for all, and that the public will not build unless satisfied that conditions are sound.

THE NATIONAL HOUSING PROBLEM: PLANNING AND ZONING

By Joseph C. Wagner,* M. Am. Soc. C. E.

Zoning is an essential element in comprehensive city planning, because it makes for orderliness in city building by endeavoring to place each building to its proper use, to construct it of the proper height, and, with the proper area, in its proper place on the city map. Thus, all industries are placed together, all business and commerce are likewise located, and all dwellings are similarly segregated.

Since planning in American cities has been almost entirely a matter of replanning, and existing conditions have had to be recognized, the effect of zoning in such replanning in the built-up sections of a city is to check haphazard development, continuing non-conforming use, but directing the placement of buildings in the undeveloped areas by fixing regulations to control future growth. It is only in this manner that nuisance-producing manufactures will be isolated in the least restricted areas, that industry will be separated from homes, and commercial business from industry.

The city plan with its basis in a comprehensive main street system, transit and transportation provisions, water-front development, parks, parkways, playgrounds, and open spaces, public and semi-public building sites, sewerage, water supply, and other public utilities, dependent largely for its carrying out on the exercise of the right of eminent domain, does not touch the right of private property in the use, height, and area of buildings affecting the housing problem, except by bringing into play zoning through the police power of government. Comprehensive city planning, therefore, is incomplete without zoning.

The housing problem is not so much a question of building more houses as it is one of building better houses under better conditions. It must also throw a mantle of protection about such houses, which indirectly will tend not only to standardize, but to increase their value for the specific purpose for which they were originally intended.

The promotion of the public health, safety, order, and general welfare, by the reasonable regulation of the location, size, and use of buildings, is affected by utilizing the police power for the limitation of the use of private property in the public interest, and is a legitimate use of that power.

Cities and Courts are beginning to recognize more and more the fact that, in the interest of general welfare, community power in these matters is paramount to that of the individual. Whatever is yielded from the individual for the public health, safety, and general welfare is yielded for the public or community purpose without compensation, because whatever is given by the individual to the community for the general welfare is received in the same measure protectively from the community for the same public welfare. A recognized authority on this subject, states that "a maxim of the police power is that every individual must submit to such restraint in the exercise of his

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liberty, or his rights of property, as may be required to remove or reduce the danger of the abuse of these rights on the part of those who are unskilled, careless, or unscrupulous". Zoning, therefore, is exercised for the general well-being.

To preserve the State in its power of government, the city must be preserved, and to preserve the city, the home, as well as industry, must be preserved and protected. On the home depends the nation. Zoning regulations, therefore, which separate home districts from intrusion by objectionable business, commerce, or industry, which intrusions tend detrimentally to affect morals as well as health and safety, will raise the standards of living as well as those of citizenship, and should be eagerly absorbed and written into the statute books of every far-seeing and foresighted community.

Philadelphia, Pa., with approximately 400 000 dwellings, a city of homes as well as a great industrial center, is vitally interested in a zoning law. In the new Charter Act, approved June 25th, 1919, the State granted the city the right to formulate regulations affecting the location, size, and use of buildings therein, and to make different regulations for different districts.

Acting under this authority, the Mayor transmitted to the Council, on October 13th, 1921, the draft of a proposed ordinance, prepared by the Zoning Commission, and this bill is now under consideration by the Council. After it is passed and approved by the Mayor, the regulations contained therein will become effective in the City of Philadelphia. These regulations provide for complete zoning by establishing use, height, and area districts, and make the zoning maps part and parcel of the ordinance. The law is not retro-active.

Use districts are classed as residential, commercial, industrial, and least restricted. Except in least restricted use, no tabular statement of permissive or prohibitive use is made, but each district is primarily designated for its special and particular use, and uses accessory thereto.

The residential districts are designated for dwellings, and accessory uses thereto, such as professional offices, private garages, and private stables only. For the fullest protection of each district in its designated use, as well as to permit flexibility in operation, special location permits are required and granted by the Zoning Commission only after public hearing. In residential districts, buildings for educational, philanthropic, recreational, or religious use, which are in no way objectionable or detrimental to the residential character of the district, are permitted subject to special location permit. These uses include club houses, educational buildings, hospitals and sanitariums, nurseries, greenhouses, places of worship, recreation buildings, libraries, art galleries, public museums, philanthropic and eleemosynary institutions, and necessary public utilities, including community heating and lighting plants, and aviation fields. A public or community garage is prohibited in a residential district.

Commercial districts are designated for commerce, general business, and the sale of commodities, and for accessory uses which may include light industry. Uses permitted in residential districts are permitted in commercial districts; other uses are prohibited. By special location permits after a public hearing, structures or uses such as accessory uses, advertising structures, community heating plants, freight transportation and storage buildings, power-

generating plants and electric sub-stations, public garages, community garages, and public stables are permitted.

Industrial districts are designated primarily for industries, manufactories, and trades and buildings used for storage, including all processes using power generated by electricity, steam, gas, oil, petrol, or other expansive or explosive force, or chemical action. Uses permitted in commercial districts are permitted in industrial districts, but those permitted in least restricted districts are prohibited. Uses permitted in residential districts are permitted in industrial districts only by special location permits. As bearing on the housing problem, if it is essential for the general welfare that residential districts must be protected from invasion by industry, it is equally as important for the proper development of industry and that it should be free from restriction by the indiscriminate placing of stores and residences in its midst, that for the same public welfare such stores and dwellings should not be permitted alongside of industry. Therefore, in industrial districts, large areas, spotted by houses for homes, if allowed to exist along with the dirt, noise, smoke, gas, and odor of industry, will tend rapidly to deteriorate and eventually become slums. As a dwelling place, the slum is unfit for any human being.

Least restricted districts are designated for buildings and uses without restriction as to the kind of use or industry conducted therein, except as defined by other laws or ordinances, and shall include such uses as are excluded from other use districts. In this district, no dwelling is permitted other than for the use of such watchmen and caretakers necessary for the protection of the plant. The following uses permitted in this district only are here catalogued: Abattoirs and slaughter-houses; ammonia manufacturing; aniline color and dye manufacturing; asphalt manufacturing and refining; blast furnaces; cement, lime, and sulphates manufacturing; chlorine or bleaching-powder manufacturing; coal-tar products treatment; creosote and wood preserving use or manufacturing; fat, grease, lard, and tallow rendering and refining; fertilizer manufacturing; fish smoking or curing and shell grinding; garbage, dead animal, offal, or refuse reduction; gas manufacturing; glue, casein, size, and gelatine manufacturing; grist mills and grain elevators; industrial poisons and chemicals manufacturing; junk, scrap, metal, rags, waste paper, and rubber storing and baling; lampblack manufacturing; oil-cloth and linoleum manufacturing; oiled rubber or leather goods manufacturing; ore reduction; paints, white lead, shellac, varnish, and turpentine manufacturing; paper and pulp manufacturing; petroleum and products (refining and storing); potash refining; printing ink manufacturing; pyroxylin plastic manufacturing (celluloid, etc.); rubber, caoutchouc, and gutta percha manufacturing; sewage treatment works; stock yards; tanning, curing, and storing of raw hides and skins, leather, or hair; tar or water-proofing materials; wood, coal, or bone distillation or grinding; wool pulling and scouring and shoddy manufacturing.

In order that the legal rights of property may be protected where existing buildings or uses do not conform with the established district regulations, these conditions may be continued in any district as non-conforming.

The height districts are established for the purpose of regulating the heights of buildings by districts within the city, and are divided into five classes:

One times Height District.
One and one-half times Height District.
Two times Height District.
Two and one-half times Height District.
Three times Height District.

The number of times denotes the maximum height of any building at the street line in such district, indicated in terms of the street width, but in each height district a maximum building height limit is fixed, ranging from 45 ft. in a "one times" district to 150 ft. in a "three times" district. Above the maximum limit, a front setback is provided for in each district, varying from an increase in building height of 1 ft. in a "one times" district to an increase of 3 ft. in height in a "three times" district, to each foot of setback. Rear setbacks are fixed in each district as twice the ratio of the front setbacks in the same district.

Height exceptions are made, permitting the erection of appurtenances to buildings such as chimneys, stacks, fire-escape towers, skylights, ventilators, and architectural adornments, such as belfries, cupolas, minarets, pinnacles, spires and towers, and monuments, where such structures are not used for human occupancy and are appurtenant to buildings as mechanical or structural necessities.

The area districts are established for the purpose of regulating the areas and locations of buildings, and are divided into five classes, in each of which the area of an interior lot that may be encumbered is expressed in the percentage of the whole lot area. The districts are:

District A	30 per cent.
District B	50 per cent.
District C	70 per cent.
District D	90 per cent.
District E	95 per cent.

In the several districts there are mandatory directions for unencumbered areas in the shape of front, side, or rear yards and courts and for fixing the minimum dimensions of such.

The administration of the law is placed in the Zoning Division, Bureau of Surveys, Department of Public Works, which is the planning department of the city. Zoning certificates and occupancy permits for the erection, construction, alteration, conversion, or relocation of any building or buildings, for occupancy and use, other than residential, for every non-conforming use in residence districts, or for any subsequent change of use in a district, issue from the Zoning Division. Penalties are provided for violations.

Changes, revisions, or amendments may be made by the Zoning Commission subject to the approval of Council. Petitions for changes may be made to the Zoning Commission by the registered owners of more than one-half the total block frontage on any street between two main streets, and entitle such

petitioners to a public hearing. If, however, more than one-third of such registered owners protest against such change, the appeal for the change shall not be granted except by vote of three-fourths of the entire Zoning Commission.

In the formulation of its regulations, Philadelphia has had the advantage not only of zoning laws in other cities, but also of the experience gained in those cities in the administration and practical operation of their laws. However, each city is stamped with its own individuality, and, therefore, it is essential that regulations be made establishing the principle of zoning and the necessary attending maps with such degree of flexibility as to promote and facilitate their practical application, and also to permit free expansion as the development and evolution of the city require.

The principle of zoning is one of the fundamental elements in a wise comprehensive city plan, and will help materially to make the city not only greater, but a better place in which people may live in health, peace, and comfort.

THE RELATION OF ZONING TO THE HOUSING PROBLEM

By B. Antrim Haldeman,* Esq.

Although zoning is a comparatively new municipal activity in the United States, no movement having to deal with community development has received so much popular support wherever its meaning and intent have been made entirely clear to the people. This is undoubtedly due to the fact that it offers a maximum of protection and benefit to both public and private interests in the matter of urban development, with a minimum of expense and effort. Practically the only cost attached to the establishment and enforcement of a zoning code is that contingent to the making of the necessary surveys and district maps, the drafting of the code, and the administration of the law after its enactment. It is not too much to prophesy with confidence that, after its advantages and benefits become more generally understood, the establishment and enforcement of a zoning code will be considered as necessary in the administration and development of a city as the laying out of streets, the erection of buildings, and the construction of public utilities.

Zoning is a primary and essential element of city planning and of any thoroughly constructive and progressive program for the improvement and extension of a city, if proper consideration is had not only for the health, safety, and general welfare of its people, but also for its future progress and prosperity. All zoning codes aim at the same broad objects—the preservation of health, safety, order, and general welfare, the promotion of progress and prosperity, and the protection of the rights of property and of the rights of owners of property in such ownership and use. Zoning codes are somewhat similar to building and housing codes, but are applied in a more discriminating manner. Building and housing codes generally apply uniformly throughout a city, while under a zoning code a city is divided into districts, and the regulations may vary in different districts to provide for the particular needs of each district.

Zoning codes are established and enforced under authority of the police power of the State, and the protection and benefits derived from them are obtained without any liability for damages, as far as the use or improvement of private property may be affected by them. Police power, at least in the matter of zoning, might better be called community power, since the police have nothing to do with it. It is simply the power which the people of every State have an inherent right to exercise through proper legal channels in the interest of the public health, safety, morals, order, and the general welfare. The Courts are the agencies through which restraints are placed on the unreasonable or arbitrary exercise of this power, and any new or enlarged exercise of it, if protested, is subject to their review and approval or disapproval. It has always been zealously guarded against abuse, and its exercise has never been permitted to exceed limits reasonably necessary for the protection of the general public welfare.

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Although the Courts have placed no sharply defined limits on the exercise of the police power, they hold that it is not unlimited and that the validity of a zoning code will depend on their judgment and interpretation of the reasonableness and necessity of the protection afforded where the regulations involve a new or enlarged exercise of such power. Where it can be shown that the regulations are in the interest of the public health, safety, morals, and order, they will no doubt pass the legal test, but it is not entirely clear as to how far the police power can be extended in the interest of the general public welfare. The greatest emphasis has been placed on its use for promoting the public health, safety, morals, and order, but there are, among both lawyers and laymen, many earnest advocates of the theory that the public welfare and also the progress and prosperity of a community are almost equally important as matters of public interest which may be properly promoted through the exercise of the police power.

This view appears to be in harmony with the opinion rendered by the Supreme Court of the United States in upholding the Los Angeles ordinance in the Hadacheck case, which opinion, concurred in by a unanimous Court, states that "there must be progress and if in its march private interests are in the way they must yield to the good of the community." With this decision of the highest Court in the land as a guide, it is probable that reasonable regulations that can be clearly and convincingly shown to be in the interest of progress and prosperity, will have a fair prospect of being upheld by the Courts. This view is also supported by opinions handed down by the Courts in many cases confirming the right of municipal authorities to prohibit the erection of public garages, apartment houses, and buildings for similarly inappropriate uses in districts set apart for residential purposes.

Except in States where the constitution confers the necessary authority on cities, it is held that an enabling act is necessary to permit the enactment and enforcement of zoning codes. During the past six years, twenty States have adopted such acts, twenty-seven cities have enacted complete codes covering the entire city, and fifty-eight cities have such codes in preparation; nineteen cities have enacted limited codes and thirty-five cities have such codes in preparation.

If one may judge by the experience of the cities that have enacted zoning codes, the establishment of use districts and regulations are the most important problems in efforts toward the zoning of cities. The Courts have looked with favor on the scheme of designating certain areas for residential purposes only, but one cannot be certain just how far one can go in differentiating residential areas for different types of dwellings, and this is important in the search for a solution of the housing problem.

In acquiring land for either development or speculation, a real estate operator considers the surroundings and the best use to which it can be put before he invests his money or prepares plans for development. He takes all the necessary measures to protect himself, and in handling high-class real estate this protection is accomplished by placing restrictions on the use of property and the kind, and even the cost, of the buildings to be erected on it.

With this foreknowledge of how the property is to be developed, the operator is in a position to lay out a proper system of streets and to provide the necessary drainage and other structures in the most economic manner, and the grantees under him can feel certain that their investments in property thus protected are safe. It is a purpose of zoning to enable the municipal authorities to determine and to have equally definite knowledge and control of the general character of the future development in each section of the city, in order that the citizens may be protected in their investments as well as in the use and enjoyment of their property. This applies not only to the home buyer and home owner, but to the manufacturer and the merchant who will have greater opportunities to expand their activities if the section in which they are located is especially adapted to, and protected for, their particular kinds of use.

If during his brief ownership of property, it is within the power and authority of a real estate operator, to establish regulations prescribing the manner in which property is to be developed, that will protect his grantees and their successors for all time, or even for a few years, it should be within the power of the municipal authorities, acting in the interest of, and for the protection of, all the people, to establish and enforce similar regulations. The municipal authorities who are responsible for the progress and prosperity of the city and for the health and safety of its citizens, should have at least equal rights with real estate operators in establishing regulations to protect the interests of the people.

One of the great driving forces behind the zoning movement is the desire for better homes, with all the comforts, conveniences, and contentment that the home supplies, and for the better protection of the citizen in the possession and enjoyment of the rights and privileges of citizenship. The conservation of the health and welfare of the people is one of the most vital purposes of modern government, and in no way can this be better or more easily accomplished than through the influence of the home. The influence of the home, its amenities, associations, and surroundings inevitably mould the character of the citizen for good or for ill. The ownership of his home gives to the citizen a pride of partnership in the progress and prosperity of the community and its institutions, and any measure of proven efficiency for multiplying the number of home owners and protecting their interests should command public support. Under the slogan of "own your own home", there has been conducted for some time a very active campaign which has had for its purpose the greater encouragement of the home-owning habit among the people. This campaign has met with great success at a time when property appears to be practically at the peak of its value and when the future is more likely to see a decline in values rather than a further increase. During this campaign, many people of limited means have put all their earnings into the purchase of homes and have mortgaged their future income, and therefore, the home they have purchased, represents practically the entire savings of their life time of work. Assuming this to be the case in thousands of instances throughout the country, it appears only fair that homes purchased and held under

such conditions, should have every possible protection thrown around them to insure the permanence and stability of their value and of their desirability as homes. Under existing conditions, there is practically nothing to protect either the value or desirability of such property for home purposes, since it is quite possible that some industrial activity of a more or less objectionable nature, such as a public garage, soap factory, or boiler works, may be located immediately alongside or even surrounding it, with the result that its usefulness and value for residential purposes are ruined. Zoning would prevent such destruction of value and home interests, would protect the home owner, insure better living conditions, and probably do much to discourage the spirit of revolution and social unrest.

In almost every city certain areas may be found on which more or less of a blight has fallen through the establishment of either business or industrial activities which have decreased the desirability of property for residential purposes, and where values cannot be re-established unless there comes a demand for additional property in that district for business and industrial purposes. Under properly established and enforced zoning laws, the conditions which obtain in these blighted districts would be prevented, and a stability of use and value would be created, which would not be disturbed unless there should be a general demand on the part of property owners for a revision of the regulations permitting a change of use.

As zoning must be considered a primary function in city planning it should be given early consideration in the planning of a new town or the extension of an existing one. Before any streets are laid out or any buildings erected, the land included in the project, or in any probable extension of it, should be apportioned for the different uses contemplated, industrial, business, and residential, and their various types or classes. Exact district boundaries, of course, cannot be determined at this early stage of development, but the most appropriate and desirable locations for various uses can be roughly determined, leaving the precise boundaries to be established as the street system is projected and the land subdivided.

Topography and natural physical conditions will largely determine the most appropriate use for which any given area is best adapted. Industries, particularly large and heavy ones, should be assigned to level land contiguous to streams, where they exist, and where rail transportation is or can be made conveniently available. Business areas should also be preferably level or gently rolling land, centrally located with reference to the distribution of residential areas. There is a general tendency wherever zoning codes are being formulated to establish two or more classes of residential districts differentiated by the type of dwelling prescribed for each class. This differentiation contemplates two distinct classes defined as one-family dwellings and multiple dwellings and these may be further differentiated by type into two-family, row, group, apartment, or tenement houses, hotels, lodging houses, etc. The primary purpose, however, is to establish certain districts from which multiple dwellings, such as hotels, apartments, and tenements shall be ex-

cluded and the opportunity afforded for the enjoyment of real home life in quiet and peaceful surroundings.

The housing problem is directly affected by zoning for residential use. Row and group houses and other types of multiple dwellings that involve the intensive use of land can be much more economically constructed and provided with the necessary public utilities if they are erected on level or gently rolling land which requires a minimum disturbance of natural conditions and movement of material during development. One-family dwellings, or dwellings of the detached or semi-detached type, particularly where they occupy large lots, can be built more economically and with more satisfactory results on hilly or heavily rolling land than multiple dwellings. Efficient zoning would allocate land for the use to which it is best adapted by natural conditions as far as such allocation might be practicable. The load on the land as determined by the distribution and intensity of industrial, business, and residential use, directly affects the cost of constructing and maintaining all public works and public service. Property improvements and public service utilities constitute a large item in the cost of housing which is materially affected by the nature of the site and surroundings, and where the distribution and load limit are predetermined by a districting plan and zoning code, large economies in the construction of streets and other public improvements become possible.

An industrial area requires a street system quite different from that of either a business or residential area. It needs a less number and a less area of streets, but they should be wide, laid out in straight lines, and most substantially constructed for heavy traffic service. Other public service requirements, such as water supply and drainage, are also on an entirely different scale.

A business district requires a street system that will have ample capacity to permit the free and unobstructed movement of traffic. Business streets should not be excessively wide, and the areas necessary for adequate traffic service should be obtained by laying out the business districts in much smaller blocks than are appropriate to either industrial or residential districts. The greatest intensity of transportation and other public service will occur in business districts and must be provided for in planning the street system.

It is in the residential districts that the predetermination of the use of land permits of the greatest economies in property improvement, street layout, and the construction and maintenance of public works. After the system of main thoroughfares has been established, the development of intermediate streets for local use can be accomplished at little expense, as they require less property and less costly improvements and this is naturally reflected in the lower cost of a housing project, from which the ultimate purchaser, and the tenant, should receive benefit.

There is a difference of opinion as to whether industrial workers should live within walking distance of their places of employment, but whether they should or not, a zoning scheme which predetermines the areas to be used for industrial purposes and the areas where the workers will live, will permit the

organization of a transportation system that will give quick and direct service between factory and home.

The limitation of the height of buildings as contemplated by zoning does not greatly affect the housing problem, except in cities where it is customary to erect great apartment and tenement buildings. Such buildings should be excluded from districts allocated to one-family houses or dwellings limited by their type to not more than three stories. Where they are permitted, the height should be proportioned to the light and air space around them—streets, yards and courts—so as to guarantee proper lighting and ventilation.

Area regulations are important as controlling the density of population and assuring ample open spaces adjacent to dwellings for purposes of lighting, ventilation, and family privacy. This is one phase of zoning that perhaps is more subject to scientific determination than any other, but as yet there has been no thoroughly satisfactory method of determination evolved, and it is the phase on which there is no Court decision to act as a guide.

Perhaps the greatest general benefits that may confidently be expected from zoning will come from the development of property for the purpose for which it is naturally best adapted and the guaranty of stability of use and value through the prohibition in residential districts of structures and uses that would tend to destroy values, create blighted areas, menace the health and safety of the people, and rob home life of the privacy, comfort, and charm that contribute most to the making of healthy, happy, and useful citizens and a prosperous and progressive city.

CITY PLANNING IN RELATION TO THE HOUSING PROBLEM

By Charles M. Reppert,* M. Am. Soc. C. E.

The economic and wise development of a city is dependent, to a great extent, on the successful and practical application of a well conceived city plan, complete in all its elements. The prime objectives of city planning are to provide, promote, and encourage the development of the city in such a way that good living conditions will be furnished and that business and industrial facilities will be afforded. The lack of city planning in the past has resulted in the present housing problem. Having now convinced the public and municipal authorities of the wisdom and necessity for making the city plan, it remains to remove those practical and legal obstacles which operate to prevent or make difficult the application and execution of that plan.

The housing problem is due to the abominable living conditions in the congested districts of cities, and to the house shortage. It follows that the standard of living conditions and the evils of congestion can only be relieved gradually by building along better lines. This, to a great extent, means the building up of the outlying and partly developed sections of the city. As far as the housing problem is concerned, it means that the major street system, the first requisite of any city plan, must be laid down with reference to communication from the home sites to the secondary centers and to the centers of industry and business, with particular reference to providing adequate and convenient arteries which will promote the building up of new residential districts; and it further means that the major street system must be legally adopted and defined so that land development may conform thereto. The location and planning of secondary streets, with proper reference to the requirements of traffic and development of land, must receive greater attention and more study in detail than is ordinarily given to the laying out of the plan of the main arteries. The development of secondary centers should receive the most careful attention in order to encourage the movement of the home-seeker from the congested districts to the newer environment, where the secondary business center should be located and opportunity afforded for neighborhood and district activities and interests.

The practical result of the execution of the city plan, confined necessarily in its earlier stages largely to city replanning and chiefly directed to the construction of new main arteries leading from the residential sections to the main business center, has been constantly to increase the load on congested traffic streets and would seem to tend to ultimate strangulation of traffic in the main business centers. This is probably due to the fact that such improvements are for the benefit of the entire city, whereas the development of secondary centers is of direct interest only to those living in or interested in that district. The conditions indicate that some of the earliest steps in executing the plan should be directed toward the development of secondary centers as a means of encouraging local home building and relieving business section congestion.

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The planning of the rapid transit and utility systems should proceed with and form an integral part of the general city plan. The execution of the city plan will further be facilitated and made economically possible, and the growth of the city promoted, by the inclusion of other elements of a modern city plan, such as railroad, freight and passenger terminals, rail and water terminals, parks and playgrounds, harbor development, and the like. These are elements which contribute toward the payment of the bills for city planning, and this factor, in the last analysis, is most important.

The location and development of the main residential streets which might be termed the minor secondary streets, is a most important element in the city plan, inasmuch as on the wisdom and skill with which such streets are laid out depends, to a great extent, the economy with which the great mass of residential streets can be laid out and given proper outlets. The city plan, therefore, must set up the machinery which will make it possible properly to plan and build the minor secondary streets.

It would seem that the further one goes into the detail of carrying out the city plan, the more difficult the practical problems become. From the standpoint of the municipal engineer, moderately conversant with the status of the city plan, it would seem that practice has failed to keep pace with theory. "What shall be done" would seem to be pretty well understood, but "how it shall be done" is a problem still to be solved. A tie must be created between those who make the plan and those who will ultimately carry it out. Improved facilities for making it possible to carry out the city plan, so that it may attain its ends, must be provided, and these may be regarded as partly technical, in that a higher standard of professional service is required, which must be partly legislative in character.

The first step in the preparation of a city plan, and the most important element in this, in the mind of the city engineer, is the street system.

Next it is necessary that the city plan, comprehending the major street system and its extension by minor streets, be legally defined and adopted. Unless this is done, no city plan can or will be carried out, as the uncontrolled development of the city will make it financially prohibitive. The writer has been much interested and impressed by a paper by Mr. Frank B. Williams, entitled "Enforcing the City Plan", which was presented at the Pittsburgh meeting of the City Planning Conference, and was submitted by Mr. Williams in the discussion of the paper by Arthur S. Tuttle, M. Am. Soc. C. E. Mr. Williams defines very clearly the nature and importance of the problem of enforcing the city plan.

The advantages which the State of Pennsylvania enjoys under the so-called Act of 1913, under the terms of which mapped streets are protected from encroachment by new buildings, has been stressed in recent discussions. The writer's observation, from experience with attempts to enforce this Act in the City of Pittsburgh, leads him to believe that public opinion will make it impossible to rely on this statute, in its present form, in enforcing the city plan. It appears to him that the Act is confiscatory and inequitable in its operation and, unless unusual conditions obtain, it will not be carried out. The City of Pittsburgh has a City Planning Commission, operating as one of

the departments of the City government. A most excellent major street plan has been prepared by a group of citizens—the Citizens Committee on City Plan—and a zoning ordinance is under preparation. A well conceived plan for the street system is now available, but there would seem to be no possible means, under present legislation, of enforcing or legally adopting the plan. Those projects which can be carried out in the next few years, will probably not be greatly affected, but necessarily the program is one which covers a much longer period for its execution. It would seem absolutely necessary that, if street location, planning, and construction is to be carried out with proper reference to the controlling factors, or if it is to be carried out at all, the State laws should provide for district assessment, excess condemnation, and the protection of mapped streets. The necessity for these provisions is more apparent in a city where the topography is rugged and where practically the whole area which will be developed in the next few years, has already been laid out in lots and streets.

The restrictions imposed by the old land subdivisions and recorded locations of streets, and the absence of necessary legislation, now make it practically impossible to lay out new streets with proper regard to location, economy, and relation to topography. As a result, building operations are not encouraged.

The technical branch of city governments must be improved. A higher technical service is required, and city engineering departments must be raised to a standard where they can, at the proper point, take over the carrying out of the city plan. If the engineering department fails in its execution of the plan, the plan itself will fail. Precise surveys should be made and the city monumented, and reliable base maps should be prepared; otherwise, the cost of the technical details will be such that the plan will fail in practice.

The municipality should have not only a city plan, but a carefully considered program for carrying it out, and this means consideration of costs and return—return in increased taxation and in service to the city and its taxpayers and residents. There is always grave danger, in view of the divergent interests of various sections of the city, that a plan will not be carried out in its logical order, with the effect that the resources of the city may be dissipated without positive results. Certain improvements will have a natural priority over others just as the foundation of a house must be built before the superstructure is commenced, and the necessity for a city plan program will be evident, owing to the fact that it is possible to build the superstructure of the plan, before its foundation. The order in which the plan is carried out is as important as the plan itself.

Properly conceived and wisely executed, the plan will pay for itself in increased valuations from taxes. The City of Pittsburgh has just widened one of the down-town streets—Second Avenue—from 45 ft. to 80 ft., and the increase in valuations of property abutting on this thoroughfare has been enormous and would seem to justify the improvement without much regard for the greater benefits which have accrued in relieving down-town traffic congestion. The same may be said of the so-called grading of the "Hump district," which was carried out in 1912, and which involved the reduction in grade of some of the most important down-town streets, by as much as 15 ft.

In the writer's opinion, the greatest defect of city planning is the lack of regard for that which is financially and physically feasible. The factors of directness and capacity in many cases would seem to over-shadow that of cost and economy and there would seem to be a disposition on the part of the city planner not to do the thing at all unless it is done in the best possible manner. The city plan, before its adoption, should be subjected to thorough review and criticism by those most familiar with construction difficulties and costs, and the final plan should be modified in such particulars as feasibility and cost dictate.

If conditions were ideal, the planning of cities would be carried out co-operatively by the property owners, realtors, engineers, and architects, under the direction of one skilled in the broad problems of city planning. Such is not now the case, as each element interested carries out its work independently and without much regard for the other. The war-time housing activities of the Government have been the nearest approach to such an ideal arrangement. The writer believes that much can be done by securing co-operative action between the city on one hand and real estate and property owners on the other, and that the establishment of some kind of a board having jurisdiction, with proper facilities for appeal, over property subdivision and the laying out and legal location of mapped streets, is entirely feasible. Such a board was suggested by Mr. Williams in the paper previously mentioned; and after a review of such various methods as have come to the writer's attention, it would seem that the future of the enforcement of the city plan lies in the general direction indicated by Mr. Williams. In any event, when a municipality takes action, whereby the property owner is prevented from enjoying the use of his property, there should be some commitment for compensation. Relief from taxation, temporary occupancy under restrictions, limitation of the period of prohibition of building on a mapped street, a commitment by the municipality to carry out the actual improvement within a given period, and such other provisions as may be devised to protect the equity of the property owner and enable the enforcement of the city plan, will have to be considered.

It is apparent to-day that the problem of city planning is not so much concerned about the technical problem itself, as to the manner in which it can be carried out, and that the solution of the housing problem is going to be delayed for many valid reasons until some one discovers how the new vision of city planning can be carried out in an economic and practical manner.

The most important immediate contribution that can be made would be to summarize the situation, define the problem, indicate various methods of solution, and formulate model State and municipal laws directed toward the enforcement of the city plan.

WATER SUPPLY

By H. Malcolm Pirnie,* Assoc. M. Am. Soc. C. E.

Present-day standards for public water supplies are high, and the majority of American cities are delivering water from their supply works that meets these standards. The water from the supply works passes through iron distribution mains to the taps of the consumers and, in many cases, deteriorates considerably so that the tap water does not exhibit so high a standard of purity as that recorded at the point of delivery. The reasons for this reversion in quality are being studied by water supply engineers and chemists, and they present variable and extremely interesting problems. The house builder and house-holder, however, are interested, as a rule, solely in the water as it is delivered at the tap and seldom give much weight to the reports of its condition at the supply works.

If the source of supply is known to be polluted by sewage, and in spite of reports of a clear, colorless, and odorless effluent from the purification plant, the consumer occasionally draws turbid, colored water from his faucet that gives a disagreeable odor and taste, his suspicions concerning the safety of the supply are immediately aroused. He will believe his own eyes and nose to the discredit of those of the plant superintendent and will discount the fact that the difference is due to physical and chemical changes which take place in the distribution system and pipes in his own house. If he is occasionally troubled with gastro-intestinal disturbances, he will blame the water supply and exonerate his favorite dish of oysters on the half shell or similar uncooked delicacy. Just how far his fears are groundless, however, and how far there may be some reason for them at times, is still a matter of speculation, although recent developments in the field of water purification point to the necessity for better methods of control and additional laboratory tests in the operation of some plants.

Next to the question of the safety of the water that of its corrosive or incrusting properties is of interest to the house owner. Suppose five or six years after a house has been built, the plaster on the ceiling becomes wet in one or more spots; the cause is traced to leaks in the piping of the hot-water supply, and the pipe is found to be eaten through by the action of the water on it. It would not satisfy the owner to know that the standard methods of testing the water at the supply works had always shown it to be alkaline in its reaction. The water delivered at his tap acted as an acid on his pipes, and he would call it acid in spite of the records. An almost equally burdensome trouble occurs in the services and house plumbing in some cases where chemically softened water is supplied. The pipes gradually cake inside with deposited salts until water will no longer run through them, and then they have to be taken out and cleaned or renewed. Thus, corrosive and incrusting waters increase the cost of housing all over the country, and they have been accepted as necessary evils for many years. It would seem that inasmuch as waters exist in some localities in a state that will not seriously

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attack or incrust iron pipes, it would be possible so to treat corrosive or incrusting waters that they would be equally passive in their action. The realization of this, however, is hindered by the multiplicity of causes making methods applicable in one particular case inefficient or even detrimental to the process of purification in another case.

A soft water is always desirable from the standpoint of a house-holder. It requires less soap than hard water, is much more satisfactory for cooking, and makes it possible to wash clothes clean with less rubbing and, consequently, less wear. A soft water, however, is often more corrosive than a hard water, and this is particularly true when chemical treatment is used in the process of purification. The question of how much a soft water should be artificially hardened to reduce its corrosive properties has not been answered in general. Untreated soft waters are often furnished without any attempt to adjust their chemical properties so as to reduce their tendencies to attack the pipes, and attention has been directed toward the installation of brass pipes in houses in place of the usual galvanized steel pipes. It is obvious that this method of solving the problem increases considerably the first cost of building, and it is doubtful whether it is the proper solution. Iron must still be used in the distribution system, and a corrosive water will deteriorate in quality while passing through it. On the other hand, if the water is treated to make it passive before it enters the distribution mains, it will be delivered at the tap in much better condition, and the necessity for brass house pipes will disappear.

Besides the sanitary quality and physical attractiveness, the corrosive or incrusting tendencies and degree of hardness of a tap water, the house-owner is interested in the service pressure. This is dependent on three factors, namely, the pressure at which the water is delivered to the system, the relative elevations, and the adequacy of the distribution pipes. A small distribution system should be designed for fire protection, and, therefore, should have a capacity much greater than that required for the ordinary consumption of water. If the pressure drops considerably at the service during the usual hours of maximum consumption, it is certain that the street mains are inadequate for proper fire protection, and should be reinforced. The question of proper service pressure and fire protection is a simple problem in hydaulics and, therefore, can be expressed in figures both as to size of pipes and as to cost per service. The cost will vary according to local conditions, but will be less per service where the houses are near each other than where they are spaced far apart.

It is a fact that some waters do not change appreciably in passing through distribution systems, whereas other waters do change, and a comparison of the chemical and bacteriological examinations of the two types of water, fails to explain satisfactorily the reasons for the difference. In these circumstances, it is necessary to look for explanations along lines that would not be indicated by the present standard methods of water analysis. The character of a city water supply is actually observed by the citizens at the taps, whereas, in a great many cases, the records of its physical and sanitary properties are made from samples collected before it enters the distribution system. When

it is discovered that a tap water falls below the accepted standard of purity, it will be wise to increase the efficiency of the various steps in the purification process so that the residual impurities in the water delivered to the city may be eliminated as far as practicable.

Contrary to a common impression, water purification is not developed to such an extent that a water recently polluted can be made as pure as the best spring water. Ordinary treatment by either slow sand or mechanical filtration will not suffice to remove all the impurities resulting from heavy pollution by sewage and, in these circumstances, it would be the part of reason to multiply the lines of defense against the chance of disease-producing agencies passing on to the consumer. A good general rule would be to multiply the steps in the purification process in direct proportion to the maximum concentration of pollution in the raw water. Practically, this would mean no purification for pure spring and well waters, free from iron and dissolved gases; plain mechanical or slow sand filtration for reservoir or lake waters, with scattered rural populations on the catchment areas; filtration followed by chlorination, if there are sewered towns near the point of taking; and, for the treatment of a river water in which there is an unusually high concentration of sewage and industrial wastes, there might well be used all the following: First, chlorination; second, chemical treatment to produce optimum coagulation; third, storage of sufficient length to allow the most persistent sols time to be coagulated and to equalize variations in the dose required and that applied; fourth, rapid sand filtration; fifth, aeration; sixth, slow sand filtration; and, seventh, chlorination of the effluent. On first thought, these seven steps may seem superfluous, but the speaker has reason to suspect that a plant which used all these steps, with the exception of the fourth, allowed water to pass that may have been the cause of an epidemic of diarrhea on more than one occasion, when the second step was neglected or only partly carried out. There is always danger of something going wrong with any one of these steps, so that the others should not be used alone in treating a polluted water.

It is evident that the cost of thorough purification of a polluted water is also, in general, directly proportional to the concentration of pollution, and when this is thoroughly recognized there will be a greater tendency to pass over the polluted source near at hand and to go to a source where pollution can be controlled within satisfactory limits. It is clear that it would not be expedient to go so far afield in the search for pure water that no money would be left for the promotion of other health measures, such as the anti-tuberculosis and anti-malarial campaigns. Ordinary processes of filtration supplemented by chlorination have so nearly eliminated water-borne diseases, even in cases where the source of supply is grossly polluted, that the resources of the community served with filtered water should be directed toward the reduction of other diseases for the present. Where improvements in purification can be made at little additional cost, however, they should be carried out, and wherever the margin of cost between a supply from a polluted source and that from a source relatively free from pollution is small, the decision should be in favor of the latter.

In a recent paper before the American Water Works Association, the speaker pointed out some relations between colloid chemistry and water filtration which seemed to indicate explanations of many phenomena in water purification. An analogy of considerable importance was shown between the protective action of organic colloids on suspensoids and the possibility of a similar protective action on suspensions of bacteria. The following quotation* is of interest in this connection. In writing of suspensions of bacteria, it is stated:

"They thus stand between suspensoid and emulsoid sols, and on this account have been represented as suspensoids, protected by an emulsoid sol, * * *.

"When the immune serum is added to the bacteria sol, the latter becomes much more sensitive to electrolytes. * * * It would thus appear that the agglutinin in the immune serum destroyed the protecting part of the bacteria sol, which thus became a suspensoid sol."

There seem to be excellent grounds for believing that bacteria protected by adsorbed organic colloids exist in polluted waters and that if they do exist, some of them will pass the filters and chlorination process unharmed. The protecting colloids may keep them from starting colonies on gelatine or agar plates, and thus they would not be detected. Later, in the distribution system, possibly due to the action of ferric ĭon, the protective action may be destroyed, and samples of tap water will show the presence of bacteria when the results at the plant were negative. The acceptance of this theory makes it easy to explain the apparent return to life of bacteria after filtration and chlorination and the variable longevity of *B. Coli* and *B. Typhi* in different waters. If this is the correct explanation of these phenomena, it is of the utmost importance to reduce the residual organic matter to a minimum, at all times, in the effluents of plants treating polluted waters.

The reduction in the colloidal organic matter is quite marked in slow sand filters, if the load is not too great, and is probably due to biological processes, but the reduction is usually negligible in rapid sand filters in the absence of coagulation. Chemical treatment is necessary, therefore, for the complete removal of organic colloids, and the use of alum alone for this purpose interferes with the chemical balance of the water by making it more corrosive. The application of soluble alkalies to offset the effect of the alum is adverse to the efficiency of the alum reaction as the hydroxal ion peptonizes the emulsoids, increasing the total surfaces which, in turn, require more alumina for coagulation. It might be said that if the water likes to eat iron give it iron to eat before it gets at the pipes, but this method of pacifying the water has its drawbacks in cost and in difficulty of removing the dissolved iron. A recent method of treating water to counteract the acidity due to the alum reaction has been the addition of powdered calcium carbonate which probably adsorbs the excess hydrogen ions together with acid cations, so that the hydrogen ion concentration in the effluent is practically the same as that in the untreated water. There is a commercial product acting on this principle—a mixture of crushed alum and powdered calcium carbonate—that is said to be giving excellent results in several plants treating soft colored waters.

* Taylor's Chapter on "The Applications of Colloid Chemistry to Biology."

The standard methods of water analysis will not indicate what treatment must be applied to a water to reduce corrosion and until the present tests have been considerably expanded, it will be necessary to experiment with each supply before the proper method of chemical application can be found for it. It is hoped that it will be possible in the near future, through the elimination of emulsoid sols, with their tendency to protect bacteria, and to carry with them adsorbed acids, and the scientific control of the hydrogen ion concentration, to reduce greatly the corrosive properties of water supplies and to put an end to the common apparent increase in numbers of bacteria in the distribution system. If this can be accomplished, the present deteriorated condition of many tap waters will disappear. The consumer will then draw from his faucets a water approaching in quality the high standard maintained at the effluent from the filters.

Not until recently has the large and useful field of colloid chemistry been applied to the study of water purification, and it has been found that many of the reactions observed in this special chemical field are analogous to phenomena that have long been noted in water purification. Mention has been made of the action of organic colloids in protecting minute suspensions, including suspensions of bacteria, because if this theory has been found to explain the reactions observed in colloid chemistry there is no reason why it should not apply to the processes of water purification. It is easy to visualize the adhesion of a coating of organic matter about a bacterium and to reason from this what its protective action might be. Such a coating could easily prevent the bacterium from sticking to the sand in the bed of a filter and through soaking up chlorine could prevent the chlorine from reaching the enclosed bacterium. Furthermore, these organic particles through their power of soaking up acids may carry the acids through the filters to become active in contact with iron and heat in the distribution system and house piping.

It is not reasonable to expect that colloid chemistry will give the final solution of many problems confronting the water-works engineers and chemists, but it is certainly a step in advance. Modern methods of water purification have succeeded in delivering effluents of excellent physical and sanitary qualities. The largest problem before the water engineers and chemists of to-day is that of delivering to the consumers water that will be as good in appearance and apparent health properties as when it leaves the purification works.

THE BASIC PRINCIPLES OF THE PUBLIC SEWERAGE OF MUNICIPALITIES

By W. L. Stevenson,* M. Am. Soc. C. E.

The sewerage of towns is necessary to protect the public health through the prompt removal and disposal of human excreta, to provide for the comfort of the citizens, and as an important aid to municipal expansion and development.

As long as men live isolated from one another, it is generally possible to obtain drinking water from a well and to dispose of excreta and other wastes on the surface of the ground, provided proper precautions are taken. Town life, however, changes these conditions; the smaller tracts of land and the proximity of dwellings make it unsafe to obtain drinking water from a well surrounded with cesspools and privies.

With town life also comes the popular demand for a bountiful supply of safe drinking water, the desire for inside plumbing fixtures, and for fire protection, which eventually results in the installation of a public water supply, and this, in turn, creates a need for the prompt removal of the spent water supply, the sewage from dwellings, the industrial wastes from factories, and the abatement of nuisance caused by kitchen and laundry water in gutters. With paved highways comes the need for prompt underground removal of storm water. All these demands, therefore, lead to a public sewerage system.

The officials responsible for the public works of towns do not realize sufficiently that the installation of a sewer system is an engineering problem involving technical knowledge and that economy of municipal funds may be secured through the engagement of a competent sanitary engineer.

It is not uncommon to find that the sewering of a town is begun by laying, say, an 8-in. pipe down a certain street, because there are houses along it the owners of which desire sewerage facilities, and no heed is given to the relation between this particular sewer and the whole drainage area of which it ultimately will or ought to become an integral part. The result of this haphazard procedure is that when the town grows, and it becomes necessary to extend the original sewer, it may be found of insufficient capacity, or otherwise laid so that it cannot be extended, or its outlet may be at too low an elevation to be connected to a future intercepting sewer.

Its ultimate uselessness is a sheer waste of public money, which could have been avoided by the preparation of a comprehensive sewer plan prior to construction. An engineer seldom has an opportunity to prepare such a plan for an entirely unsewered town and, therefore, the first work should be to obtain complete information concerning all known existing sewers, in order that as far as possible such as are suitable may be incorporated in the comprehensive plan. The main drainage areas of the entire municipality should be determined from the topography and the street plan, and practicable and economical locations selected for the main and sub-main sewers of each area.

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For the built-up parts of the town site the complete sewer system can be designed in detail, with fairly safe assurance that future development will be provided for and that only in case of unusual changes will relief sewers be necessary in the years to come.

For the drainage areas or parts thereof at present undeveloped and for which no definite street plan has been adopted, the tentative location of the main and sub-main sewers may generally be determined from the topography. An experienced engineer can estimate the probable future density of population and quantity of sewage per capita, and also the storm water, with sufficient accuracy to estimate the run-off and for these data determine approximate sizes and gradients of the proposed main sewers of the undeveloped areas.

In the design of the comprehensive plan consideration should be given to the probable future admission of sewage or storm water from those parts of drainage areas of the town at present outside the municipality, for it must be remembered that flowing water does not recognize a municipal boundary line even though it crosses a drainage area. Topography not political boundaries should govern in sewer design.

In the future, annexation of such outlying territory or agreements between contiguous municipalities may make co-operative sewerage economical of public funds and in that way justify the original increase in capacity of certain sewers of the comprehensive plan.

The comprehensive plan should include at least tentative practicable alignment, sizes, and gradients of intercepting sewers, that the outlets of main sewers may be designed with such elevations that without excessive costs for pumping or reconstruction all the sewage of the town can be conveyed to a suitable site for treatment. This should be done even where it is not necessary to treat sewage at the present, in which case, general outline plans sufficient to demonstrate the feasibility of sewage treatment should be prepared.

Where the town site includes areas of appreciable size of both high land and low land, consideration may be given to the design of two lines of intercepting sewers, the higher to convey sewage by gravity to the treatment works and thus reduce the volume of low-level sewage which will have to be pumped. However, this does not always prove to be economical, as sometimes the lessened rates of flow of low-level sewage, due to the diversion of the high-level sewage, may require gradients so much steeper on the low-level intercepting sewer that the cost of construction is seriously increased by the deep cut in a possibly wet trench due to proximity to a stream.

A decision must early be made in the preparation of a comprehensive plan of sewerage as to the use of the combined or separate system of sewers and although many elements enter into this problem, usually the controlling factors will be the kind and extent of existing sewers and the relative economy, as determined by comparative estimates of the cost of construction plus the capitalized annual charges of each system.

In the older towns, rain-water culverts were constructed along the beds of streams flowing through the town site and, later, utilized for the conveyance

of sewage. This practice developed into the so-called "combined system" of sewerage, in which the conduits are made of sufficient capacity to receive the run-off of storm water on the drainage area, and the sewage is also carried in the same conduit as the rain water.

Later, it became the practice in many American towns to provide sewers exclusively for the conveyance of sewage and industrial wastes and to construct an entirely independent system of conduits for the removal of storm water. This method of sewerage is known as the "separate system."

It was thought that the separation of sewage from rain water by means of the separate system of sewers would be complete protection to streams, as all the sewage could be conveyed to treatment works, even during times of storm, and also as the volume of sewage to be pumped or treated would be considerably reduced through exclusion of all rain water from the sewage conduits. In actual practice, however, these results are not obtained. Rain-water connections are made to the sewage conduit and sewage connections are made to the storm-water conduits, both willfully and through ignorance, and thus frustrate the anticipated purpose.

In many cases a small town at first can only afford to install the sewage conduits of the separate system, and must tolerate the storm water flowing along the street surface until the municipal finances permit the construction of the supplemental storm-water conduits.

In towns having large drainage areas with relatively flat topography, the combined system is more likely to prove the cheaper, while in smaller towns, especially in those with rugged topography, traversed by streams, the separate system will probably be the less expensive as the storm-water conduits will be relatively short, because they can discharge to a near-by stream and thus will not attain such a great length and large size as if they drained the larger flatter areas.

For diverting the dry-weather flow of sewage and the first flush of storm run-off from a combined sewer system to an intercepting sewer, and for permitting overflow of excess storm water to the stream, there are many devices in use. Most of them include a dam across the invert of the combined sewer and a gate for the admission of sewage to the intercepting sewer, controlled by a float governed by the height of the water either in the intercepting sewer or in the combined sewer. Those devices with the fewest moving parts are most likely to be economical in both constructing and maintenance and, what is more important, to be reliable in service.

The widest variation in rate of sewage flow will be obtained from short drainage areas having relatively steep territorial slopes and, conversely, the least range from large flat drainage areas. Also, small streams having pools or sluggish velocities need a higher degree of protection against storm-water overflow containing sewage than large streams with relatively high velocities. These factors must be borne in mind, in connection with intensity of storms, in determining the depth of flow in the combined sewer at which overflow may be permitted.

It is most important in designing sewers for the collection of either sewage or storm water to make careful estimates of the future development of the

area to be drained, in order to determine the ultimate run-off which the sewer will probably have to carry. Not only the average rate of flow should be estimated, but also the maximum rate, and, in addition, a factor of safety should be used to insure against future maximum flows causing the sewer to become surcharged. Minimum flows, especially during the period before complete development, should be considered, lest too low velocities occur and result in deposits and foul sewage.

The restrictions of a zoning code have a direct influence on the design and economy of a comprehensive plan of sewers. Industrial areas probably will produce the highest rate of sewage flow per acre. Closely built-up residential areas will produce higher rates of flow per acre than the open development of suburban residences. In a town built on a sloping site, on the bank of a stream, it is probable that zoning regulations will confine the industries near the banks of the stream, and the open residential area will be at or near the high land. These conditions make possible the use of sewers of relatively small capacity at the summit ends and do not require provision for the highest flows per acre until the lower ends of the sewers are reached.

Fresh sewage has practically no odor, but in stale sewage the decomposition of the organic content is the cause of offensive odors. Therefore, the sewer system should be designed, constructed, and maintained so that the sewage will be delivered to the place of disposal or the treatment works in the shortest practicable time and at such velocities as will prevent deposition of solids. Therefore, sewer inverts should be laid on straight gradients, junctions should be made so as to prevent the formation of eddies, minimum velocities should not be below 2 ft. per sec. and the interior surfaces should be made as smooth as possible.

Thorough ventilation of a sewer system is also needed to help retard the decomposition of the sewage and to reduce the hazard to workmen who may enter the manholes or the sewers. At least on new sewer systems, house sewers should be directly connected, without the use of the "main house trap" and ventilation provided through the main house stack of the plumbing system. Such ventilation makes unnecessary open-top ventilating manhole covers which, when located in other than most durable street pavements, afford opportunity for grit, cinders, and other detritus to enter the sewers from the highway and, in the absence of high velocities, cause deposits in the sewers or, if carried forward, cause trouble in the sedimentation tanks at the treatment works.

In all cases where sewage must be pumped or treated, or where such may be required in the future, the infiltration of ground-water to the sewers should be reduced to an economic minimum through the use of tight joints in pipe sewers and impervious construction in masonry sewers.

Since industry is the life of many communities, it should be encouraged, and not hindered by restrictive legislation prohibiting the use of sewers for the conveyance of suitable industrial wastes. The treatment of industrial wastes at the point of origin is costly, oftentimes prohibitively so, unless by-products can be recovered. It is to the interest of a community to receive suitable industrial wastes into the public sewer system, except those which

may injure the structure of the sewers, interfere with the free flow of the sewage, seriously affect the successful operation of sewage treatment processes, or cause tastes and odors in public water supplies taken from the stream receiving the sewage.

In cases where industrial wastes are accumulated in tanks in the factory, the peak load on the sewer system or the possible difficulty in operating the sewage treatment works can be reduced materially by the discharge of the industrial waste over a relatively long time rather than by intermittent discharge in large quantities.

Sewer systems like any other utility, require maintenance. Just because the sewers are unseen and underground, they are usually neglected. If deposits form they should be removed, and damage to the structure of the sewers should be promptly repaired. How else can the sewers render efficient service?

The main sewers of a town are almost always laid in the valleys of the drainage areas and therefore convey the sewage to some near-by watercourse. This means that the water-borne filth of the town is transferred from the premises to some body of water.

The conservation of natural resources in the surface waters of the United States demands that streams and other bodies of water must not be rendered unfit for normal use by the undue discharge of sewage into them, and several States have enacted laws to control the matter.

The protection of the public health requires that streams used as sources of public water supplies shall be maintained in such a condition that the water can be purified safely, at a reasonable cost, and made fit for drinking purposes. Common decency calls for clean streams, that is, free from nuisance to sight and smell of sewage origin. Therefore, the degree of treatment to which sewage should be subjected, in order to meet these requirements, varies between wide limits, depending on the use and conditions of the receiving body of water.

Disposal of sewage by dilution is a proper scientific method in cases where there is an ample flow of water to assimilate the sewage inoffensively and maintain the stream in a clean condition, and where the discharge of sewage will not endanger a source of public water supply, shellfish beds, bathing beaches, or other uses requiring a hygienic standard.

Where the receiving body of water cannot assimilate the crude sewage, but can receive the dissolved and non-settleable solids without danger of nuisance or menace to the public health, the required degree of treatment can be obtained by sedimentation of the sewage to remove solids of appreciable sizes, or even in a few cases by fine screening.

The separation of the deposited solids or sludge from the liquid part of the sewage, as in the Imhoff tank, or where the sludge is removed to a separate sludge digestion tank, materially tends to prevent the increase in the oxygen demand of the tank effluent, which occurs when the decomposing sludge is in direct contact with the settling sewage. In small installations, however, where efficient operation is not likely to be obtained, the much abused septic tank often proves far more successful than many idealists believe. The real

difficulty in the sedimentation of sewage is in the de-watering and final disposal of the resulting sludge, and not in securing an effluent free of settleable matter.

Undue economy in design in order to reduce cost of construction frequently results in the sludge compartment of sedimentation tanks being too small to permit retention of sludge long enough for thorough digestion of the organic matter; and during the operation of the tank the careless withdrawal of the sludge places on the drying bed a more watery sludge than need be and one containing undigested organic matter. These are the causes of the offensive odors during the slow drying of the sludge. With a tank of proper design and with skillful operation, the danger of nuisance from drying sludge on sand beds is reduced to a minimum.

In cases where the receiving body of water cannot assimilate the putrescible dissolved and non-settleable matter in the effluent of a sedimentation tank, further treatment is required to reduce the oxygen demand. This may be obtained through oxidation by means of the trickling filter, contact bed, or intermittent sand filter, as may be deemed most economical or suitable to local conditions.

Where the conditions, the distance, and time of travel between the point of discharge of partly or completely treated sewage and the intake of a public water supply are insufficient to insure an appreciable death rate of the pathogenic organisms in the sewage and produce at the water-works intake a raw water susceptible of economical and safe purification, the disinfection of the sewage effluent should be adopted as an additional safeguard.

Both chlorinated lime and chlorine gas are used for this purpose, the quantity depending on the organic content of the sewage effluent and the degree of removal of bacteria required. A solution of chlorinated lime may prove more reliable than chlorine gas, because of the slower action of the former in permitting an opportunity for penetration of solid particles.

The addition of a chemical germicide to crude sewage naturally can only affect the bacteria present in the liquid, in small particles and on the outside of large particles. When, later, the large particles disintegrate, they liberate the organisms which have been unaffected by the germicide, and the fancied protection is nullified.

In their design and operation sewage treatment works involve many scientific principles. Successful and economical results cannot be obtained except through skillful design and intelligent operation. A sewage treatment works can no more run itself than a power plant, and yet many municipal officials think it can, and act accordingly.

In conclusion: Every municipality should have a carefully prepared comprehensive plan of sewerage and construct the various sewers thereof as necessity arises and funds can be made available.

The sewers should be designed, constructed, and maintained so that they will promptly convey the sewage in as fresh a condition as possible to a proper place of disposal.

The degree of treatment of the sewage should be sufficient to maintain at all times the receiving body of water in a clean condition and fit for normal reasonable use.

LEGISLATION AND FINANCING

By Allan Robinson,* Esq.

The housing problem is not the problem of the rich or the moderately rich, so much as it is that of the poor or the moderately poor. There are numerous vacancies to-day in New York City in the houses occupied by the well-to-do, but there are practically no vacancies for the poor. Such vacancies as do exist, have been created, in part, by new construction of better class apartment houses and, in part, by a migration from the city into the outlying districts. The poor, however, cannot migrate; they must live near their work. The rents of the poor have risen quite as much, proportionately, as the rents of the rich, and they have met this increase either by doubling up wherever possible, or by moving into poorer and less sanitary quarters. There were a great many vacancies in former days in the cold-water flats, but these flats are now filled with families who formerly lived in steam-heated apartments. The menace is great where a large part of any community is compelled, by economic conditions, to lower its standard of living. No true solution of the housing problem will be reached until ways are found to furnish homes to people of moderate means.

Statistics indicate that a great deal of building is now being done in New York City and vicinity. The Building Trade Employers Association reports the following comparison for the period from January 1st to December 10th, in the years 1920 and 1921:

	1920	1921
Manhattan	$96 686 325	$121 862 741
Bronx	18 130 600	65 043 648
Brooklyn	55 985 373	90 341 510
Queens	32 701 277	72 984 340
Richmond	7 990 485	3 551 550

This construction will provide homes for 21 730 families, and predictions are made that a greater amount of construction will be undertaken in 1922 than in 1921. Although these figures are encouraging at first glance, they are not convincing. On the contrary, an examination of the causes which are responsible for the present building indicates that there are certain fundamental defects in the situation, which are anything but encouraging. In the first place, this spurt serves to keep up the wages of the building tradesmen at a time when wages in all other trades are receding. In the second place, the types of buildings that are going up do not offer any real help to the people who most need homes. At present building costs, accommodations cannot be furnished at less than $15 per room per month, and this is more than the average skilled workman can afford to pay.

Furthermore, not only are the single-family and the two-family houses that are being built on the outskirts, erected only for sale and not for renting, but the apartment houses that are going up in various parts of the city are

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being erected by builders for the sole purpose of sale. Investors are not helping to-day. The largest builders in Queens County are no longer building apartments to rent. One of the largest and most important companies in the Bronx cancelled a $1 000 000 development after it had erected only $250 000 worth of buildings, and the Realty Associates, in its last annual report, made the following statement: "Because of the effect of the rent laws passed by the Legislature in 1920, the Realty Associates has practically ceased the construction of multi-family buildings and assistance in financing them." On the one hand, there is an artificial stimulation of speculative building growing out of the effect of the tax exemption ordinance, and on the other, there is the retarding effect of the rent laws. As time goes on, and the period of tax exemption grows shorter, the effect of the tax exemption ordinance will weaken. As long as the rent laws are in effect, investment building of multi-family houses will be practically nil. Therefore, the appearance of prosperity in the building trades should not deceive, but should direct, at the earliest possible moment, thoughts and energies toward modification of the rent laws, so that tenants may be protected and investment funds attracted to the building market.

Mortgage money is more plentiful to-day than it was a year ago. A short time ago eleven institutions banded together and offered $2 900 000 for building loans. Already 435 building loan mortgages have been financed from this fund, and a promise is made of more money for this purpose. The Metropolitan Life Insurance Company states that from January 1st, 1920, to December 16th, 1921, it has loaned $18 774 357 on 5 068 dwellings and $49 205 750 on 589 apartment houses, or a total of $68 080 107. Of this large amount of mortgage money, which has been made available for housing purposes, $45 680 200 has been placed in Greater New York. Although these and other institutions are making generous appropriations for housing, private funds, which in ordinary times would seek the mortgage market, have been withdrawn from it. The reason for this is not far to seek. Mr. Clarence H. Kelsey, President of the Title Guarantee and Trust Company, states that:

"The present high surtaxes make 6% mortgages actually produce very little more than 3%, and so they are much less desirable than other securities. Farm loan bonds are exempt from the income tax. There are more than $20 000 000 000 of exempt securities in this country already. * * * Men who are in the business of attracting money into the mortgage market see very plainly that there are only two practical remedies, one is to reduce surtaxes, so that money will not be sucked into the tax exempt securities, and the other is to exempt a given amount of mortgages * * *."

The exemption suggested by Mr. Kelsey is the same as that recommended by Senator Calder's Committee on Reconstruction and Production. This Committee reported in favor of an amendment to the Revenue Act of 1918 to exempt from taxation interest on loans up to $40 000 on improved real estate used for dwelling purposes, when such loans are held by an individual. If there is going to be any sucking of funds into tax exemption securities, let some way be found to suck them into building mortgages. Tax exemption is not defended, but as long as it is recognized by the law, it should be extended so as

to provide protection where protection is most needed. At present, the effect of tax exemption provisions works in the interest of the rich. The exemption suggested would tend to help the poor, because it would attract capital into the moderately priced houses.

The true solution of the housing problem, however, is not to be found in legislation or in making available a greater amount of mortgage money. The true solution is in the production of low priced homes, and these cannot be produced with labor costs at their present levels. There has been an improvement in labor efficiency in the last year. At the cost peak, efficiency was not over 50% of the normal. Bricklayers, who in the pre-war days were accustomed to lay from 1 500 to 2 000 bricks per day, in 1920 were laying only 600 bricks per day. In one case, with which the speaker is familiar, a man laid as few as 450 bricks per day, and, when the contractor discharged him for inefficiency, the whole gang of bricklayers walked out. What was true of bricklayers was also true of other building trades. The wages of building tradesmen increased, on the average, about 100%, and their efficiency decreased approximately 50 per cent. Estimates made to-day show that building costs are still 100% higher than pre-war levels, and until there is a further improvement in efficiency and a substantial reduction in wages, it will be impossible to produce homes for people of moderate means, to rent on the basis of $10 per room per month, which is all that these people can afford to pay.

The effect of improper housing is felt not only in the physical well-being of a community, but in its civic and moral aspect. Unless something is done in the near future to house comfortably and in a sanitary way, the large mass of the people, the citizenship of the country will suffer. It is, therefore, of the utmost importance that waste in building be ruthlessly eliminated, and that building tradesmen be induced to accept in their own interest a lower wage than they are receiving to-day.

LEGISLATION AND FINANCING

By Edward M. Bassett,* Esq.

The speaker has given especial attention to the subject of zoning, and he will try to cover a somewhat broader field than legislation regarding zoning. In the suburbs of New York City and in most of the large cities proper restrictions were always applied to high-class residences. It is only since zoning has come to the City of New York that the small house has had any assistance or protection, such as the private restrictions afforded to the more wealthy people; but private restrictions, even if they were adequate, were troublesome because they often resulted in litigation. They were usually fixed for a term of years and thus would not permanently affect a neighborhood after the restrictions had lapsed. Non-conforming buildings, apartment houses, and business would invade the locality where the restrictions were contradictory in character. The Courts were apt to set them aside because of a change of character approaching the neighborhood, and there was always need of celerity on the part of the private citizen in order to protect himself under these private restrictions, because if he was guilty of negligence, the Court would consider that his rights had evacuated.

Zoning has brought better protection to the homes of the well-to-do than private restrictions; but a remarkable development is perceptible in that it is beginning to protect the homes of people of moderate means. The "E" zones are residence districts, in which is permitted the construction of a building covering not more than 30% of the land. The intention was to protect good suburban development; but during the last three years there have been at least eight petitions to place the people of moderate means in "E" zones, where apartment houses and block houses are barred.

One of these localities, known as Glenmorris, in the Borough of Queens, has buildings valued at from $6 000 to $8 000, many of them, however, about $6 500. Those small homes are protected, and the person of small means who has bought one can be sure of having a home for himself and his children, thus bringing about a permanency and a desirability of small homes in Greater New York. It is greatly to be desired that even in New York, the workingmen should have his own home.

A home owner is a good citizen because he takes an interest in the community, the streets, the upkeep, and the expenditure of money by the city. In owning his own home he is in all ways a better and a more thrifty citizen than one who is paying rent. It is difficult to accomplish much in Greater New York along this line and yet the rapid transit and the zoning are bringing about the possibility of a person of very moderate means owning his own home.

The old City of New York was a long city, with a small amount of land and long distances to travel. Development during the last 12 years has tended to produce a round city, which has the greatest area for the shortest distance

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from the center. To-day, land at $700 per 20-ft. lot can be obtained fairly near good rapid transit.

Houses that sell for $6 000 to $4 500 can be produced at present prices on 30 ft. of land within 8 min. walking distance of the 5-cent rapid transit in the Borough of Queens. The production of one-family houses, however, is not going to accommodate the people of the City of New York. There is a need of multi-family houses.

Mr. Robinson has covered the fundamental considerations regarding those, and the reasons why they are not being built in New York City. Zoning has an application to multi-family houses. It does not allow the congested building of residences that could once be placed in New York City. At present, there are the "E" zones, and also the "D" zones, or about 65% zones, suitable for block houses and small apartment houses, in which is prevented the erection of unnecessary multi-family houses. There are enormous areas of "D" districts in Staten Island, Kings, and Queens.

The zoning of New York City, however, should have a more intimate relation to the prevention of congestion than was considered at the time the zoning was planned and passed by the city. It was a novel enterprise. To what extent the Courts would uphold it was unknown. It was desirable to go as far as there was certainty that the Courts would back it; and when that was discovered, the intention was, in some respects, to find methods of more adequately preventing congestion.

One method is certainly the introduction of districts in which there will be a greater percentage than in the "E" district of 30%, and less than the "D" district of 60%, something like a 47 or 50% district.

New York City is slowly becoming a better place for workingmen to have their homes. The suburbs are being opened by rapid transit as they never were before; and the increase of the periphery of Greater New York and the accessibility of this property by transit has been so great that the land available for this purpose is comparatively inexpensive.

This brings up the subject of police power. All the regulation that can be brought to the large cities, in behalf of better protection of families in their homes, must be done mainly under the police power. The police power is that power of the State, which can be invoked for the protection of the health, safety, morals, and general welfare of the community. Zoning is perhaps as generous a grant of that power as has ever been made by States to cities; and the Courts have affirmed it in the City of New York, the highest Court of the State having declared that zoning is a constitutional invocation of the police powers of the State. In all these invocations of the police power for the protection of housing, are some fundamentals that have come out clearly in the litigation that has arisen in regard to zoning. The Zoning Enabling Act, or rather the amendment to the Charter enabling the City of New York to pass a zoning resolution or ordinance, was intended to donate all the powers relating to height, area, and use of buildings.

That effort was not successful. Part of the powers were granted; and it is a splendid grant of power to the city; but if one wishes to include in zoning a limitation of families per acre, it is desirable to state in the Enabling Act

that the city shall have the power to restrict by families per acre; or if it is to be done by any other method there must be a statement that is sufficiently adequate to allow the city to exercise that particular method of establishing the police power. The speaker wishes to urge any one who endeavors to draw an Enabling Act that will grant to cities the power to protect buildings, to take great pains in the language used, preferably using broad language, that will allow the largest scope of the power. If that cannot be done, then enough should be included in the way of specification to accomplish the result desired.

Some of the zoning laws of the State are not being upheld by legal decisions, because the Enabling Acts were not adequately drawn to accomplish the zoning which the cities placed in the ordinance. In the City of New York there is a trend of sentiment that affects this question. Mr. Robinson referred to it plainly. The speaker is not sure that he can be more explicit than Mr. Robinson, but he wishes to suggest that there is a sort of social insistence—he will not call it Karl Marx socialism, but along the line of this great wave that is going on all over the world—the voter considers that by his vote he can affect the price of the things he consumes; and from that he concludes that he will by his vote affect the price to get them as cheaply as possible. That reflection of his vote operates against public utilities.

An honest public utility is as desirable for a city as an honest apartment house. It is an honest investment in something that the people need, until the city can construct and operate the same thing for them. Most of the cities, in the United States at least, have not arrived at the point where they can do that; and so the voter casts his vote in a way that he thinks is going to lessen to him the price of the thing consumed. This relates to transit and other utilities. It relates to apartment houses, as is reflected in these laws that seek to make the consumer the favored one.

It will be noticed that all these laws affecting prices to the consumer are "nailed down" in the City of New York and cannot get away. They are not, for example, like wheat, because wheat would be sent to Philadelphia, or some other place; but when a thing is actually "nailed down" in New York, there seems to be an advancing sentiment that the consumer by his vote will make the price of that which he consumes.

One of the dangerous elements in legislation along this line is that it prevents capital from coming in to build what is necessary for the consumer. Sooner or later, this delusion will stop; when the voter perceives that his apartment house, his utilities, and the things he needs, are not being afforded to him, he may then realize that one of the reasons, at least, why they are not being afforded is because by his vote he has driven to other places the capital that would increase public utilities and apartment houses.

An investment must earn a fair return and a fair return is that rate which will induce other money to come for additions or duplications of that same thing. If legislation brought about by the consumer vote makes it impossible for a fair return on new investment, then that money is going into something else. The consumer will discover that there must be a change of attitude in order to attract capital, which is absolutely necessary for the city.

One might say, the city itself can do all of these things; but the experience of Vienna was most disastrous; and in New York City the speaker presumes that until tenure of office is more fixed, until there is greater fidelity to public duties, until there is an opportunity for the public administrator to obtain a greater skill in the performance of his work, it is going to be doubtful whether the city can substitute itself in apartment houses or small homes, or in many of these other things, for the private investor; and if one can conceive that for some time at least the private investor must be depended on, then, probably, among other things, there will be a change of attitude that will attract capital to the great cities.

LEGISLATION AND FINANCING

By William H. Ham,* M. Am. Soc. C. E.

The whole housing problem is replete with disorderliness. The financing is left at a critical point by the large institutions, this being known as the point of double security. Here, it is left to be finished by those who drive sharp bargains. Construction methods have little in them that should not be changed. The styles of houses that have been most largely produced do not have the approval of architects or engineers. The people are still struggling to throw off the yoke of mid-Victorian badness in the East and what may be well styled the "near-Pullman" in the West.

During the World War and the period of activity which immediately followed the armistice, a tremendous movement of peoples took place, which, in general, was a gathering around industry. These people have usually been below middle age, for it is always youth that is mobile. They have been and are still restless—as youth always is restless—they have added a streak of independent action to the normal restlessness, because so many of them have been in the Army where home restraints were removed for the first time. They are also more independent than is usual among Americans, because of the invigoration of physical development of these able-bodied young men.

The training of the Army, and of those who stayed at home as well, has been such that there is no place left for the unsanitary, ill-lighted, badly designed, uncomfortable tenements, and the speaker is sure that in the immediate future there will be found an entirely new clientele for the new homes. This clientele will present new demands which must be recognized in the building program. The dull, dismal, colorless home which has been so profusely built in the last fifteen or twenty years must be eliminated.

Every radical change (and the building business is going through one now) develops confusion at the start. A confused state of mind is evident at the present time, regarding the building of homes, and the few clear, outstanding facts ought at this time to be emphasized so that they will have the clarifying action of public discussion and, when developed, have the endorsement of public opinion.

This Society does well to give attention to the housing problem at this time, when chaos predominates and when standardization of methods and principles are in the moulding period.

The speaker will read a few words from a leading thinker of our generation, who has given attention to the fundamentals with a clear vision, written in the mature years after an extremely busy and thoughtful life. Dr. William J. Tucker says:

"The social curse of industrialism as it now exists lies in its effect upon the disposition and temper of industrial workers. It has taken away from them the zest for work, than which nothing is more necessary to social progress. This alienation in spirit of the man from his work is as evident in the higher ranks of industrial labor as in the lower ranks.

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"Industrialism has put him under the domination of the machine; it has subjected him to various conditions not of his own choosing; and it has deprived him of the stimulus and incentive to private ownership.

"No man can be satisfied with his work, who is not allowed a share in the responsibilities and rewards of private ownership. Industrialism, under present conditions, deprives its workers of this satisfaction. It makes no provision for their individuality. It swallows up the individual in the class, leaving him in just complaint over his unsatisfying lot. And the most disheartening fact is that those who suffer most from this lack in industrialism have sought for compensating equivalents rather than for a reform of the system."

These statements, written ten or twelve years ago, stand out because of their clear expression of the cause of the difficulty, which is industrialism working its change on the community and the suffering of the individual as a result of service to industrialism.

The industries themselves are changing, and great strides have been made in some important organizations toward the distribution of ownership. The speaker refers especially to the United States Steel Company and many other companies, which have largely distributed their stock to satisfied employees on a basis of purchase within the power of the wage earner, and by this distribution have earned the good will of a large number of their best workmen.

Looking honestly at the building business to-day, one is confronted with the fact that the selfishness and unfairness of the building trades have been sufficiently exposed so that the people know there have been frauds by the cheap, speculative builder, excessive interest rates charged by the money lender, and a very low return has been given by labor, which has shirked. The industry has been hampered by bad laws, both written and unwritten, and by unfortunate customs and compromises by the builder through his associations and the workman through his trade unions. These influences have been extremely subtle and far-reaching.

Indications, however, in the buildings now under construction, show that more work is being done by the trained mechanic, because of the keen competition for the job and the speaker believes also, because the mechanic himself has learned, in part at least, that limiting his output is un-American and not in accordance with the rules of the game. However, a rational apprentice system is not being developed. Interest rates have been excessively high, but are now lowering. There is little difference between the statement of the financial leader when he says "Money must receive for interest what it is worth in the open market", and the statement of the labor union delegate when he says for his men in the union, "We can get the high wage and do a small day's work and we are going to do it". The wages of money and the wages of men constitute the principal items of cost in the building and owning of homes. Every evidence is seen of a return to normalcy.

Ten years ago, the relation between the material cost on the job and the labor cost for installation was in the proportion of approximately of 70% for material and 30% for labor. Two years ago, this proportion was changed to 40% for materials and 60% for labor, and, at the present time, it is about 50% for each. The cost of materials on the job is largely a matter of labor in itself.

The Engineering Profession should take up and study sufficiently at this time the whole problem in such a manner as to furnish to the builders of the great industrial period ahead, a clear-cut outline of available materials, efficient methods of construction, and a rational means of financing. The use of labor effectively is the one great problem for which engineers are qualified best to solve.

Let the industrial and financial groups to which the housing problem is extremely important, be assured that every phase of it has been studied with an analytical care so thorough as to eliminate all the excesses which have been so marked that the public has taken cognizance of them.

Let the engineering societies join hands with the architectural institutes, the mechanical societies, the banking group, and the manufacturers' associations in a joint effort to lay down a clean-cut specification for the materials which should enter into the construction of the homes of the people, the proper methods of building, and the proper costs for various items of construction, going sufficiently deep into the problem to reach the proper output for a day's wage in the various trades, and, in addition, establish a proper plan of finance which will insure a wider distribution of ownership.

A committee, working with broad views on this problem, will find a tremendous amount of variety in the requirements of homes and the regular human factor which enters into all our problems and, as well, a definite prejudice in regard to details and methods. All these are such that careful analysis will lead to a clear view of the proper program for building in the immediate future 1 000 000 houses in the United States.

The speaker wishes to point out a few of the fundamental items which must be reviewed, changed where found faulty, and standardized after study. These will be classified as follows: Construction items, family needs, and financial methods.

Construction Items.—Of the items of construction which will show the greatest result in economy and the greatest change in methods of building, the following seem to be the most important.

Excavation methods are wrong because they employ either hand labor or horse labor in the majority of cases. Small machines are needed and must be developed for the proper handling of small volumes of earth. Large machines for heavy excavation have been developed to the highest point of efficiency, but little effort has been made with the small machine.

Foundations themselves have been built by "rules of thumb", which have found their way into many building laws in various cities of the United States and have affected seriously the cost of construction. Foundations should be factory made, transported and erected with proper machinery as a part of the manufacturing plant equipment.

Timber framing has been used for practically all the development since the Civil War, by "rules of thumb" and not in accordance with engineering principles. Joists and studs have been placed 16 in. on centers, principally for the reason that the waste lumber which is made into wood lath, will not span any greater distance with safety; whether the span is large or small, the normal

spacing in the house of to-day is 16 in. Although some variation in the depth of the joist has been made, this variation is not in accordance with the load requirements.

Framing methods are fairly well established, but the cutting of timber in the forest still follows largely the 13-ft. rule. Tremendous waste is caused by the cut-off ends of lumber. The whole lumber industry and the use of the lumber in buildings should be standardized and put on an engineering basis.

The next item of importance is piping, which includes the heating and plumbing throughout the building. Little work has been undertaken for standardization in the plumbing industry, and that little has been resisted by the plumbing trades at every turn. Sanitation of cities outside of the buildings has been given intimate study by expert professional men, and this Society has furnished notable examples who have done a wonderful work, whereas practically no progress has been made toward the solution of the problem of plumbing or inside sanitation.

Hundreds of cities have as many different building codes, intricately drawn, authorized by a common council composed of mediocre laymen, influenced by a group of badly trained mechanics who have insisted on excesses without question, under the guise of sanitation, and not a doctor or a sanitary engineer, with a few exceptions on Government work, has ever been at a hearing or had a word to say about these building laws. Regulations in the trades themselves have limited output to an excessive degree.

The speaker will cite one example that is standard throughout many of the States. In the piping trade, no pipe 2½ in. in diameter or less may be cut in the shop by machine, but must be cut by hand on the job. Nine-tenths of the pipes in a building are probably under this diameter, therefore nine-tenths of the pipe for plumbing and heating work is still cut by man power on a temporary bench, with hand tools. All this can be overcome by standardization of the plumbing and heating layouts so that the full requirements can be shipped to the job by the factory, ready cut for installation and largely fabricated.

This item of piping alone demands the most careful study of some competent engineer who will have the courage and convictions to go into this problem with the knowledge that forceful methods will be required, since the opposition of the plumbing industry, not only of tradesmen, but of manufacturers as well, will be encountered at every turn and will continue to oppose until the strength of public opinion has given endorsement to a revision in this part of the building process.

The speaker believes the elimination of back-venting and the substitution of anti-siphon traps, with relief venting, or loop venting (which is used by the Government) should immediately be endorsed by the engineering societies since sufficient data are available to warrant this conclusion.

Plastering by the present wet process in average buildings constitutes a setback by bringing water into the building at a time when everything needs to be dry, wetting the timber and trim members, and causing a delay and serious damage to the plaster itself on account of the swelling of the materials

to which it is applied. Plastering by the wet process is wrong, and the dry finished product substituted therefor is most urgently required.

The objection to the wetness of plaster is only one minor objection. The more important objection to plaster as now applied is its continuing destruction in the house itself, which constitutes one of the most serious items of depreciation.

There are substitutes on the market which are being largely used, but they have not been developed sufficiently, either as to quality or as to size of sheet. Co-operation between the manufacturers of plaster substitutions and the architects is necessary to develop to full value the substitute materials which can be used for the inside walls of buildings. The speaker has a suggestion to offer to the architects in this particular, that is, to divide as far as possible the inside surfaces of the rooms into panels with the use of door and window trim extending from floor to ceiling and to return to the extensive use of a proper wainscot, simple in form and developed to work satisfactorily with the plaster substitute.

By this method a large part of the house areas would be reduced to small-sized units, easily transported and simply installed. The ideas of our ancestors in the exterior form of the building is returning and if these important details are emphasized on the interior, a large number of the plaster difficulties will be eliminated.

Fabrication of house parts in the shop in the locality of the building site is the next important item. By this is meant such items as door frames and trim complete, window frames in like manner, and all dormers complete to the last detail, including the window, with the hardware installed. These fabricated parts of buildings, to be made by standard shop drawings, transported in the fabricated state, and installed by men trained to this kind of work, will lower the cost of construction and, at the same time, give the architect an opportunity to express himself, because the work is done under mill conditions and in the locality where the house is to be built.

In the construction of small buildings there are hundreds of items which will lend themselves to the same analysis as the few mentioned.

Family Needs.—The needs of the family can be discussed at unlimited length and still leave unsaid much of importance. The fundamental principles of demand and the reasons therefor as they apply to the home of the workingman, classified by the industries as a "wage earner", and the small salaried man who is a step only above the wage earner in independence of action, can be codified quite simply and the speaker has undertaken to set down those items which emphasize themselves most clearly, as follows:

1.—The workingman to-day demands a decent home.

2.—The minimum requirement for one family is entirely different from the minimum requirement of another family in the number of rooms. The minimum demand changes during early married life with the advent of children.

3.—The workingman will seek as near as possible a minimum which satisfies his requirements.

4.—Three rooms and bath constitute a minimum and make an exceedingly popular unit. Next in popularity is four rooms and bath; next, five rooms and bath; after that, six rooms and bath in an individual house.

5.—The workingman to-day demands a share in ownership. This demand is not fully crystallized, but should be stimulated as a great stabilizing influence in manufacturing communities.

6.—To-day he will undertake a contract which appears to be free from paternalistic influence, if the start in the form of payment is small. This is absolutely proved in the housing work in Bridgeport, Conn.

7.—It is not practical to build a three-room individual unit suitable for fee simple ownership. The same is true of a four-room unit. The five-room unit is the smallest individual house that should be built. The six-room house is the best isolated individual unit.

8.—The workingman must pay the price that is necessary for a decent home, and the wage must be sufficient to allow the payment for a decent, economical home.

9.—The large amount of money necessary to support a home-building program demands that the funds shall come from the people who work, and in small units.

10.—The money will be obtained more cheaply directly from the people than from any other source. The demands from the people for use of their money are two: Safety of investment and liquid character of investment.

11.—Cities grow in proportion to the number of families that are satisfied and not in proportion to the birth rate. Rapidly growing cities attract young people, because it is youth which is mobile; therefore, it is incumbent on these cities to provide homes for young people and that is what Bridgeport has done.

12.—Unattractive home units will interest only those with sharp practice and speculative plans in mind. The attractive home interests both those who are in the employer class and those who are in the employee class. The many visitors to the Bridgeport project is evidence of this influence. Simplicity and good taste are fast taking the place of extraneous frills. The growth of this new style will be made clear to the worker by a slower process than to the employer, but will surely find its way into the popular mind during the next few years.

13.—A plan of graduation from the minimum three-room unit to a permanent fee simple ownership of the six-room house is desirable, and Bridgeport has built its houses with this in view.

14.—Economy demands the three-room home as a temporary dwelling only. The four-room unit should follow the three-room home with the advent of children, and the five-room unit should follow the four.

If there were no houses and no customs to contend with in the building trade, the problem would have fewer complications for the building of the various types of homes that are required to meet the family needs, could proceed. This is not the case and, therefore, what is here must be used as far as possible and additions built thereto, which will, when completed, make the whole structure a harmonious product. There are bad tenements and many

of them; these must be rebuilt. There are many oversized, ugly houses which must, of necessity, have something done to better their value and improve their appearance.

As the speaker sees the program of addition, it divides itself into three distinct items of construction and each of which are important.

The first item is the organization for and the building of a large number of small unit homes, in groups over industrial cities wherever vacant spaces are available. These groups are to take the form of a village within a city, each community having its common playground and private gardens. These small homes are to be variable in size and to be so small in number of rooms as to reach the minimum requirement of small families of the working classes, but, at the same time, furnish proper surroundings for ideal living conditions with the home. These homes must be in part owned by the people who live in them, and the investment which represents their true value should be divided so that it can be readily distributed to these people who begin living in the city village and owning some small share, that share growing week by week.

The speaker would go so far as to make the shares of ownership extended to the beginners in family responsibility and home purchase a liquid investment so that it can be exchanged readily for a larger and more pretentious home of the same or other development, or for a first investment in an individual home.

The second form of building clearly demanded by the people is the small individual house, averaging six rooms and bath to each home, built on its own lot. These small, well-built houses should be constructed from carefully prepared plans and should be sold on an installment basis to those who have a sufficient amount of money to make an initial investment, equal at least to the risk in the property. The organization of a building program for these homes should carry with it the opportunity of exchanging part ownership in the "city village" previously described, for the first investment in a house which is to become the property in fee simple of the occupant.

The third item, which is no less important than the other two, is the rebuilding of run-down tenements in the slums and the raising of these to a standard which will qualify as an American home for the lowest wage earners. Some of these structures are so bad that modernization is impossible, and they should be eliminated. Most of them, however, will yield to a radical re-building process and give results which for a temporary expedient, at least, will suffice and save a tremendous amount of construction cost.

A real program of rebuilding to bring these inferior homes up to standard should be outlined, and standardization of all such items as are possible should be introduced.

The problem of multiple-family homes on expensive land in large cities is another function of the housing problem which needs study and which should incorporate the distribution of ownership to the individual and the introduction of community amenities commensurate with the class for which this type of housing is built.

Financial Methods.—The speaker has confined this paper, principally, to three forms of homes. Although this is not all the program, it is a definite

and substantial part, and leads directly to the necessary phase of the situation, which in reality is the subject given in the announcement for this paper, namely, the financing of homes.

The city village is the most idealistic and probably the hardest to finance from two standpoints, of any of the types recommended. The first of these is lack of knowledge on the part of the people who control and direct the money; and, second, because of the necessity, in order to secure successful results, of bringing into this financing the small savings of many people.

It will be necessary, for a start to be made in building up of these "city villages", for wealthy individuals and corporations of high standing to underwrite the initial expenditure, distributing the ownership at a later date to the individuals. A large apartment-house movement has already started in some of the largest cities along this line. Co-operative ownership is not recognized as much in America as in England, but still there is the marked example of the building and loan association or co-operative banks, as they are called in some of the States. These are increasing at the rate of $500 000 000 per year in assets and are simply co-operative institutions founded on the integrity and confidence in members and borrowers.

From experience with the management of four of these city villages, the speaker is convinced that harmony of interests can be readily developed, and a supporting influence of pride will spread with wholesome contagion.

The next problem is the financing of the individual home which some time is to be owned in fee simple by the more prosperous, further advanced thrifty worker. This has less call to the imagination, and can be simply stated as to its source of capital and the method of accumulation of ownership by the purchaser. To every family of good repute in every industrial city, there should be offered an opportunity to buy such a home when this family has, by thrifty saving or otherwise, accumulated $1 000. This amount, if the home is built on a proper basis and of durable materials, will represent all the risk of loss that such buildings in the average should show.

Association of capital in a program that will produce these homes and protect them with proper and definite surroundings, and wholesome restrictions, can bring better results to that community than any other form of investment that the group of financial men can support.

The definite, clean-cut demand on the part of the people for a method of buying is simple, easy to follow, and good financing, is understood by the people, and is already in practice in many places. This definite, concrete demand of the people is for a form of deferred payments on home property in a single monthly installment, with definite amounts established. The use of a first, second, and, sometimes, a third mortgage, each with their hazards and complications, and the vicious bonus system now thoroughly established, are disliked by the people, who wish to buy at a fair price and who can buy and pay for the house, with proper interest rates, when it is built at a fair cost value.

This great problem of furnishing the money above the initial payment of the purchaser, which averages much less than half the cost, is one which

must be woven into the banking and other institutional finance, in such a manner as to use the great volume of money available through the savings institutions and the National banks, insurance companies, building and loan associations, and the private lenders.

The tremendous amount of money available for first mortgages on one-half of the value is evident. To-day, $400 000 000 is available through the National banks for one-year loans on real estate direct. Savings banks and trust companies have an equal or greater amount available in the same way, but for a longer period. The building and loan associations are increasing assets, available for long-time loans, at the rate of $500 000 000 per year. This last agency is the only one that can legally advance very far beyond the double security point.

Mr. Walter Stabler, of the Metropolitan Life Insurance Company, has outlined the possibility of a close co-operation of the already established building and loan associations and the insurance companies, and the speaker wishes to quote briefly from a paper by him, presented to the Chamber of Commerce of the United States, in January, 1921, as follows:

"This, therefore, brings us back to the proposition of first mortgages of 50% being made by insurance companies, savings banks, and other lenders through, or in co-operation with, the Building and Loan Association, with the associations making the additional loan up to a total of, say, 80%. I am not aware that such a plan has ever been put into effect, certainly not to any great extent, but I feel very sure that it is safe for all the parties interested and that it should provide large sums of money, not now readily available. Such funds could be secured in the briefest possible time and without the red tape apparently inseparable from Governmental agencies. I hope the associations will give it serious consideration. I believe it is a question, the solution of which, is largely in their hands. They can by this, or similar means, provide the second mortgage money, so much needed and so difficult to obtain, to which I referred in the early part of this paper."

The financing of the rebuilding of run-down tenements is a private matter that can be largely influenced and stimulated by co-operation of the loan institutions and the speaker suggests this as a means toward the development of a wholesome beginning in rebuilding.

Let the lending institutions in the industrial cities publicly offer to increase the mortgage loans on run-down tenements to the amount of added cost of improvements, if these improvements are made in accordance with a standardized rebuilding method, outlined by some substantial organization which shall, by its merits, have public endorsement.

Let the industrial cities, through their governing bodies, exert the full police power to eliminate the bad character of buildings and urge their improvement by force of this police power. In many cities there are buildings that are so far below the standard that the power of the city to close them could not be questioned. This power should be exercised for the betterment of the condition of living, and should be done at once.

Let a committee from these associations which have been mentioned, and such others as should be taken into the problem, formulate a clean-cut program, endorsed and approved by all, and let this program be publicly distributed

through the various channels available, such as building supply houses, banking institutions, and the architectural and engineering society journals, and a result of harmony in the whole problem may be expected.

The speaker offers this as a suggestion with the recommendation that it be formulated into a resolution of this Society through the proper channels, a suggestion to this effect that this Society propose to the American Institute of Architects, American Society of Mechanical Engineers, American Banking Institute, the Building and Loan Associations of America, United Building Material Association, and the Manufacturers' Association of the United States, that a joint committee of three or more from each association be appointed for an early conference on this subject, which conference is to be under the auspices of this Society, and that the different associations authorize their representatives on this joint committee to proceed to the examination of, and the reporting on, the problem of housing in America, to issue at the earliest possible date a progress report, and to continue such investigation until a complete and joint committee report can be issued and published. The speaker would suggest further that, through proper channels, funds be appropriated with which to employ a clerical force sufficient to make a thorough examination of present conditions and in general to care for the needs of the committee in the formulation of its program.

Each of these associations should be requested to appoint for this work able and expert men, leaders in their line, whose findings will be recognized as authoritative.

As a further suggestion, the speaker would recommend that this Society appoint one man, to give his entire time to the formulation of the report and the carrying through of the necessary investigations, and to act in an executive capacity as secretary chairman of the committee.

LEGISLATION AND FINANCING

By John Ihlder,* Esq.

Three statements belong at the beginning of any discussion of these two allied subjects, for they are allied in fact as well as by a conjunction.

First.—Whereas, before the World War any mention of the housing problem conjured up visions of slums inhabited by a submerged tenth, to-day it conjures up visions of the comparatively well-to-do, including United States Senators, fighting against increased rentals. Before the war, we had to remind our hearers constantly that housing is a community problem affecting even the well-to-do. To-day, we have to remind them that it is a community problem affecting even the poor.

Second.—Yesterday, to-day, and probably for several to-morrows, we shall have to remind them that financing a house includes more than first cost.

Third.—We are called on to-day to emphasize as never in the past, that the neglected field of management is of first importance, and that if it is developed as it should be, it will give us valuable knowledge which can be applied in devising sound laws and financial policies.

Because the housing problem is to-day affecting the well-to-do, it is securing an amount of attention never before given it. For the well-to-do are vocal; they speak for themselves without any urging. As a result there has been a great deal of housing legislation during the past two years, and probably this year will add to it, which legislation bears somewhere in title or text the word "emergency", which is not based on any deep study, and which is designed merely to check, temporarily, certain abuses from which a vocal part of the community is suffering.

Such legislation is dangerous. Designed, not to cure, but simply to reduce irritation, it is likely to have effects quite unlooked for. Those who live in New York need not be reminded of some unlooked for effects. Probably no one expected that the Courts would be quite so unable to agree on what is a fair rental, that they would within less than a year be more than 100 000 cases behind on rent trials, and that between \$10 000 000 and \$12 000 000 of rent money would be tied up awaiting judicial decisions. Whatever one may think of the landlord, however exclusively his sympathies may be with the tenants, he cannot be pleased with these effects, for they interfere with progress toward the only solution that will solve, that is, the erection of an adequate number of good houses.

Of course, some wise people did foresee, if not exactly these particular handicaps, at least some check to building activity because of these anti-rent profiteering laws; they prepared an antidote to be administered at the same time as the poison. This is the law exempting new dwelling-house property from taxation for a period of years. For the past two or three months they have been pointing at the official figures of the number of permits issued and the estimated cost, and proclaiming that the antidote works.

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In New York there has developed to an unusual degree the habit of drawing conclusions from local experience. It is found that more homes and more tenement houses have been built in 1921 than in 1920—New York has a tax exemption law applying to 1921 construction—but what about the scores of other cities and towns throughout the country in which were built so much more housing during 1921 than during the year before?

The speaker will read from a letter which he received recently:

"The name of this city, Columbia, S. C., was not in the published list of cities with good building records for 1920, though that list was taken from information furnished by your department of the Chamber of Commerce of the United States. We, therefore, call your attention to the following facts and ask that you make amends for leaving out of this list the name of a city with a remarkable 1921 record. By August 31st, 1921, the value of building permits issued in this city in 1921 exceeded the total value of building permits issued during the whole twelve months of 1920."

There are cities other than New York, and some of them are quite as self-conscious.

Among the reasons given for building activity in these other cities are the continued pressure of demand, together with considerably reduced prices and a canny suspicion that prices may go up again. Did not these have some effect in New York?

The point in all of this is, that the value of such legislation as described is not proved. The speaker would go further and say that it has been exceedingly harmful in that it has, during these strategic years when public attention was focused on housing, diverted that attention from a real consideration of the subject, a consideration which might have led to results of permanent value, into blind alleys of expediency. It is not wholly flattering to New York to say that it should be the leader in working out a solution of the problem. What is meant, is that New York is so bad—from the housing point of view at least—that it cannot get much worse and some solution must be found.

It was New York that led the way in securing the kind of regulatory legislation that has permanent value with its tenement house law and its zoning ordinance. These are no mere stop gaps with emergency written into them, but are examples of constructive statesmanship. To be sure they are not fit for other cities to adopt as they stand, for they had to be made to fit the intolerable conditions of New York. They, however, established sound principles of legislation. Other and more fortunate cities can adopt and have adopted those principles to their lasting benefit, by changing the details of standard to fit their conditions. This is the kind of service that it was hoped to secure from New York during the past two years, and which it is still hoped may be secured before public interest begins to flag.

The tenement house law, fragmentary as it is, for it does not cover one-family and two-family houses or hotels, lodging houses, and similar dwellings, was the precursor of the much more nearly complete housing codes adopted by the more progressive cities and States. Its essential provisions are simple, though the language in which they are clothed sometimes is not. They provide for:

1.—A definite minimum area of open space on the same lot with every dwelling.

2.—Definite minimum sizes of living rooms.

3.—Definite minimum window area.

4.—Adequate and convenient water supply.

5.—Proper toilet facilities.

6.—Possibility for family and individual privacy.

7.—Protection from the weather.

8.—Protection from fire hazard.

9.—Proper maintenance.

The reason for bringing these into a discussion now is that many self-styled, hard-headed and practical people believe that such legislation will check building. The speaker believes that the contrary has been practically the universal result. In New York City itself, in New Jersey four years later, in Columbus, Ohio, in Michigan, wherever it has been enacted, such legislation has been followed by increased building activity, for it has made investment more secure. This is a bond that allies legislation with finance.

The enactment of zoning legislation may be expected to have the same effect, although statistics are not available in proof, because most of the zoning laws have been enacted during the abnormal times since 1916.

The enactment of these two kinds of laws and the improvement and greater uniformity in building codes, are aids in overcoming the housing shortage, because they increase the security of investment and, therefore, tend to invite investment money.

As to other kinds of housing legislation of a more direct action variety, there is still too little knowledge to permit of confidence. Three years have been wasted on securing emergency measures of doubtful, or more than doubtful, value, even as emergency measures, and with few or no supporters as permanent measures; perhaps a beginning can be made by adopting certain tests.

In the first place, let people get over the idea that they are facing an emergency in the sense that it is a short-time proposition. With the best of good fortune the obvious housing shortage will not be overcome within the next five years. By this is meant that the vocal well-to-do will not be as adequately provided with good housing in 1927 as they were in 1914. As for the wage-earners, let alone the poor, their problem will be with us a great deal longer. Consequently, it is the part of common sense to base proposals on the proposition that the campaign will be long continued and that whatever is to produce results must be economically sound. These are the tests. During the World War the speaker was an advocate of Government housing for war workers. That was a time of real emergency, and it had a definite terminal point, the end of the war. To-day, the situation is fundamentally different. What is done now has no definite terminal point. Any date that may be set is easily changed, and what is done now establishes precedents and habits of mind which will carry on. Therefore, it is important that these precedents, these habits of mind, have in them the possibility of continued growth and

development. Adequate and good housing must pay a fair return on the investment. Only thus can enough good, new housing to meet the growing needs and rising standards be assured.

If this is accepted, there is a wide field for Governmental agencies—which means legislation—that can be no more than hinted at here.

First, real information is needed. A little pamphlet, "The Building Situation", published by the National Chamber of Commerce, with the co-operation of the United States Bureau of Labor Statistics, represents an attempt to secure such information. During the past year (1921), the Federal Department of Commerce has established a Division of Construction and Housing, which is beginning, as has been stated, to assemble and distribute such information. The continuance of its valuable work calls for legislation. This should be supplemented by the States and cities. California and Indiana now have Governmental agencies that will contribute, and other States should follow their lead.

Next, means must be sought for reducing the cost of housing. This will undoubtedly call for legislation. The extent of this field alone is indicated by the work of the Lockwood and Dailey Committees and by the conferences of Secretary Hoover with representatives of trade organizations. Obviously, there are practices, customs, and inhibitions, due both to law and to convention, that can be changed and, being changed, will reduce costs and at the same time strengthen private initiative or assure fair profits.

Here, perhaps, is the best place to say that, as far as experience goes, such short cuts to the millennium as Government building and management do not promise to reduce real costs. Government operation, not only in the United States, but in other countries, has, as a rule, proved clumsy, inefficient, and expensive. Certain functions must necessarily be performed by Government, but the burden of proof is always on those who would transfer new functions to the Government. Thus far, it seems to the speaker, proof is lacking that Governmental construction or management of housing would produce better or as good results in America as private management. At the same time, however, those who hold to this belief must recognize that dissatisfaction with present housing conditions is causing a growing sentiment for direct participation by the Government. The only effective answer is to produce better results through private operation.

In brief, then, the kind of housing legislation which, because of experience, can be counted on to aid, is regulatory. This kind would protect the man and would contribute to the public wealth from the exploiter who would prey on the public. This kind of legislation: Building codes, housing codes, city planning, and zoning ordinances should be perfected and promoted, because well devised building will be encouraged and investment will be made more secure.

Beyond this there is a wide field for original work. In this field, however, the notion of an emergency must be discarded and the fact that the problem is chronic must be faced. That being true, proposals must be economically sound, and must have in them the possibility of continued growth and development.

Under the question of finance certain facts must be faced, namely:

1.—The cost of a house is not its purchase price alone. A house is not immortal, though some owners of antiquated structures would have us so believe. There are as yet no mortality statistics such as the life insurance companies have to guide them along paths that avoid bankruptcy: but it would probably be quite safe to assume that the average life of a city dwelling is thirty years. The cost of the house is its total cost during those thirty years, with the assumption that at the end of that period it will be scrapped. The speaker admits that this expectation of life is an assumption and that an assumption of 40, 50, or 60 years may be nearer the fact. Whatever the period, however, there should be figured into the cost of the house:

(*a*) Interest on the investment;

(*b*) Taxes;

(*c*) Repairs;

(*d*) Fire insurance;

(*e*) Depreciation and obsolescence fund which will equal the cost of the house.

This is on the assumption that the house will be occupied by its owner. If it is an investment proposition, allowances must also be made for:

(*f*) Periods when the house will be tenantless;

(*g*) Cost of management;

(*h*) Water rent, unless the tenant pays this.

2.—Housing, as a rule, has not been financed on any such basis as that mentioned. Speculation and sentiment have been the mainsprings of action as far as one-family and two-family houses are concerned, and speculation alone as far as multi-family houses are concerned. Most of the housing troubles in pre-war days, the worse troubles that are lying in wait for us now and will arise as soon as the present shortage has been overcome, are due primarily to disregard of these economic factors in housing.

Much is heard these days of the difficulty of securing mortgage money. The speaker will merely refer to this difficulty in passing, as an indication of how superficial the discussion during recent years has been, how far short of the root go such proposed remedies as laws compelling certain kinds of banks to loan certain percentages of their funds on dwelling-house property. There was once a time when men of moderate means and men of wealth invested their surpluses in housing property. In the older cities are still remnants of large estates which consisted in great part of dwelling-house properties, groups, rows, or blocks of houses bought as an investment. Along with many other things, these housing estates were pretty well done for during and since the war. The sale prices were too much for human trustees to resist.

The change, however, had begun long before the war. Men were still buying investment houses—the speaker is not discussing New York tenement houses now, but the typical American one-family houses—but they were changing their practice. To illustrate: One such investor would buy a row of new houses from the speculative builder and hold them for ten years. He

then would sell to home-owners, and buy another new row. His explanation was that repair bills began to increase after ten years. The home-buyers, being amateurs, did not know this.

This explains a large part of the difficulty in financing. The old-time investor went out of the market because deterioration in quality of houses was forcing him to become not an investor, but a trader. This deterioration did not affect the mortgage market so greatly, because mortgages usually run only for a short period; they are practically never as long lived as the shortest lived house. So the mortgagor like the trader, usually got out before serious trouble began. In some places, however, deterioration both in construction and in type was so rapid and so widespread that long before the war certain bankers in New England, for example, began to refuse even mortgage loans on wooden three-deckers.

Here, it seems to the speaker, is a key to the financing problem. Make housing once more a good investment, and capital will be available. The appeal of housing investments does not and should not be in an expectation of large returns, but in an expectation of sure returns and on security for capital invested. Investors have been led away from this conception by "get rich quick" schemes, by tales of fabulous increases in land values that more than made good depreciation of building values; and so they have come near to wrecking the house property market.

If there is anything sure in this world, it is that not enough houses will be secured if home buyers are depended on. The census figures for 1920 indicate that there actually has been a decrease in home ownership during the decade, 1910-20, despite the housing shortage which forced so many to buy as an alternative to camping in the streets, despite "own-your-home" campaigns conducted on a scale and with a vigor never before attempted.

Honest, substantial construction is essential to success in tempting investment money back into this field, construction which recognizes that the cost of a house is not fully paid until the house is scrapped, that repair bills are an important item, and that even more important is the decrease in value due to the hopeless shabbiness of a "jerry-built" house after it has lost its first freshness.

In the housing codes and the zoning ordinances, municipal authorities are aiming at stabilization of value. These efforts will be useless unless they are supplemented by good construction.

The third and last point—management—will be discussed very briefly. The theory that every one-family house is to be occupied by its owner has played into the hands of the shoddy builder, and has led to utter disregard of housing property management. In the old days, the big estates did develop the principles of management to some extent, but as these estates were split up, as the number of small rental properties increased, the practice grew of farming them out on a commission basis. The results are familiar to all. There is no more generally recognized antagonism than that between house owner and tenant. It has actually become accepted as a law of nature.

Why this relationship should be different from all other business relationships is a mystery to those who believe that it is inherent. It is not inherent;

it is simply due to bad management or to lack of management. Along with his belief that his building is immortal, the house owner seems to believe that the house-rental business is the only one that can run itself. He is a belated disciple of the late lamented Keeley, who demonstrated perpetual motion. So if success in financing housing is to be attained, we must:

1.—Give housing property a real investment value. This is being helped by housing codes and zoning ordinances. However, honest building must supplement these. Honest building means sound construction plus good planning and adequate provision for such essentials as outdoor space, light, air, and sanitary conveniences.

2.—Begin to study housing property management. Office building managers are working out the principles of their business in their annual conventions. During the past two years, a few apartment house managers have contributed a little from their experience. As yet, however, the small house managers have not appeared.

It will not be enough to encourage the individual investment buyer to re-enter the field, however. In other lines of business, the individual has been supplemented by the corporation and in the apartment-house field the corporation has appeared. It should enter the small-house field and with its entrance should also enter the field of the tenant stockholder. Other lines of business have found it good policy to have participants become stockholders. Apartment house corporations are trying the experiment. In their case the speaker is frank to confess that he does not see much hope of substantial and long-continued success. The apartment house has so little of the home appeal, and is so essentially a mere stopping place, that most of the attempts to make it co-operative will prove short-lived. With the one-family dwelling, however, the case is entirely different. There the prospects are bright, once a traditional attitude of mind is overcome.

The speaker has suggested no easy roads to a solution, no panaceas that will work a transformation over night, no appeal for the Government to do what the people have to do for themselves, because all these mean simply a waste of precious time followed by disillusionment. A long, hard job is before us and the sooner it is started the more likely it is to succeed.

DISCUSSION ON THE NATIONAL HOUSING PROBLEM

By Messrs. Eugene W. Stern, T. Kennard Thomson, Nelson P. Lewis, John Ihlder, Henry H. Curran, Edward S. Rankin, and Benjamin A. Howes.

Eugene W. Stern,* M. Am. Soc. C. E.—One phase of the housing problem—and a very important one—has not been touched on, that is, the question of financing. It has been stated that the way to solve the housing shortage is to build more houses; but one of the great difficulties to-day is the impossibility of getting money at such reasonable rates of interest, as will enable the builder to construct and compete in price with the houses built under more favorable conditions.

The gross cost of a building is made up of a number of items, one of which of course is the actual builder's cost. Another, but a most important one, although not often thought about in this connection, is the cost of financing the building operation from its very beginning to its completion, and it is surprising what a large item this becomes to-day in the total cost of construction.

In New York City, and in other cities of large population, the building of homes or tenements has been undertaken in the past almost entirely by professional builders who have specialized in this class of construction. They are the ones who have constructed those huge rows of houses, likewise the vast majority of tenements and apartment houses, which one sees in all large cities. They are in business to make money on their ventures, as they should. Private individuals who build their own homes are such a negligible factor in the housing situation that they need not be considered. The speculative builder of low-priced tenements suitable for working people to-day has practically ceased operations, and one of the reasons is the fact that he cannot borrow money at reasonable interest. Money rates are high at present, and it seems likely that these high rates will prevail for a long time. As long as the Governments of the world, particularly European Governments, are willing to pay from 8 to 10% for money loans in the United States, it cannot be expected that builders can get money at 6 per cent. The speaker is informed on reliable authority that the cost to them is anywhere between 10 and 15 per cent.

The speaker believes that here is a situation in which the State can help very materially, namely, by assisting in financing housing projects. It has been done in France for more than half a century by an organization semi-governmental and semi-private, whereby long-term loans extending to 20 or 30 years, amortizing annually and on reasonable rates of interest, are made to people who desire to build.

Although the high cost of building to-day is partly due to combinations among material men and manufacturers to boost prices artificially and is another factor in the creating of high rents, in the last analysis, one of the most important, if not the most important of all the factors which enter into

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this complicated problem to-day, the speaker believes, is the inability to finance housing construction on reasonable terms.

T. KENNARD THOMSON,* M. AM. SOC. C. E.—Attention has been called to the relative cost of labor and material, which is generally assumed to be about "fifty-fifty" or "forty-sixty". Those are about the proportions for work done in New York City, but the 50% allowed for cement, steel, and the other materials used, means that the contractor who produces such materials has already put in about "fifty-fifty" for labor and material; therefore, as a matter of fact, the total amount actually paid to labor, if traced back to the mine, factory, cement works, etc.. would be a much larger percentage. It would be interesting to know what the percentage really is that goes to labor.

Mr. Purdy referred to the fact that the pollution of the soil is no longer permitted in Lower New York, but pollution has existed so long, with possibly unknown leakages still going on, that New York quicksand has received a disagreeable odor. If one will walk up to the top floor of an old building in the lower part of Manhattan, about three or four o'clock in the morning, he will probably detect this disagreeable odor.

The discussion so far has been principally on how to rectify the present deplorable conditions by zoning. There is another feature easier in some respects, and much harder in others, that is, what restrictions for regulating the height and size of buildings, etc., should be made in laying out a new city. In laying out the Towns of Pullman, Ill., and Gary, Ind., it was possible to obtain all the space needed, and the purpose for which these two towns were built, was more or less restricted.

NELSON P. LEWIS,* M. AM. SOC. C. E.—It is unlikely that a few years ago the subject of Housing would have been announced for consideration at a meeting of civil engineers. The speaker is glad to note that times have changed and that engineers are disposed to take an active part and interest in questions of this kind. It has often been said that congestion does not necessarily mean the number of people to the square mile, or to the acre, but that it is indicated by the number of people in a room, and just as bad housing conditions can be found in sparsely settled communities as in great cities—sometimes even worse —although in the former case such conditions can be more readily corrected.

It has been stated that it is difficult to induce people in suburban districts to buy and retain lots of a size greater than barely to accommodate a house and a garage; this statement is significant and somewhat disturbing.

The suggestions given for apartment house design, and the statement made as to the satisfactory results to both owner and tenant, are quite encouraging. The question naturally suggesting itself is, "Cannot some policy be adopted that would encourage less intensive use of ground area in both apartment house and detached house districts?" The assessing and taxing officials might endeavor to place a premium on more generous allowance of land in housing enterprises by fixing the assessed value of the land, for purposes of taxation, in accordance with the area occupied. Assessments appear now to be fixed according to the potential value of the land, provided it can be covered to the

* Cons. Engr., New York City.

utmost permissible limit. Suppose, for instance, assessing officials, who are usually allowed great latitude, should fix, for each locality, a unit land value, which might be different for every block, and wherever plots have been built on they should fix, as the taxable value, such percentage of that unit value as would be determined by the percentage of the area of the lot built on. For instance, it has been pointed out that the old type of apartment house covered 79% of a plot 100 ft. square and that the proposed new type covers only 62 per cent. For purposes of illustration, assume that where buildings cover 80% of the lot area, the land should be assessed at its full unit value already established, and that where less than 80% is covered, the value should be fixed at a figure inversely proportioned to the proportion of the lot occupied. For instance, if 62% only is covered, this represents 77½% of 80%, and the assessed land value on a plot so improved, therefore, might be fixed at 77½% of the normal value for this particular district. On the other hand, if 90% of the plot was covered, this 90% being 112½% of 80%, the assessed land value, in this case, might be fixed at a value 12½% greater than the unit value already established. Possibly constitutional objections would be found to the formal adoption of such a policy, especially if it were to be given legal sanction, but it has already been pointed out that assessing officials have much discretion, and it might be well to try out such a policy, the legality of which might have to stand the test of Court proceedings.

Westchester County, in New York State, has been, as far as the speaker knows, the first county, at least in this part of the United States, to establish a County Planning Commission. Probably the Commission has not yet attempted to exercise much authority, but it is a hopeful sign. If counties contiguous to great cities do not themselves attempt to control development, it will be necessary, in the public interest, to give the cities themselves some degree of jurisdiction over the planning of territory beyond their corporate limits. This has already been done in many cases, and a recent canvass of 27 typical cities made by the speaker shows that in 10 of them the City Planning officials have jurisdiction varying from 1 mile to 15 miles beyond the city boundary. In the case of the other 17, which included both New York and Philadelphia, there is no jurisdiction whatever outside the city limits.

In his paper, Mr. Wagner has drawn attention to the desirability of excluding residences from districts devoted to heavy industry. This appears to the speaker a perfectly logical thing to do. If such industries are forbidden to invade districts set apart for human habitation, because their presence will be injurious to health and comfort, it is just as logical to say that buildings for human habitation shall not be erected in places set apart for such industries.

John Ihlder,* Esq.—If the plans presented by Mr. Thomas† do what he claims for them, they are revolutionary. In housing, the great fight has been against constantly greater and greater land overcrowding. The evil effects of land overcrowding as applied to considerable areas and over long terms of years

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† The paper by Andrew J. Thomas, Esq., will appear in a subsequent number of *Proceedings*.

can be demonstrated, and because of this the zoning ordinances were secured. The individual lot owner, however, still believes that the more building he can crowd on his lot, the more profit he will make, because he believes that this crowding gives him more rentable floor space. Of course, he admits that if his neighbors follow his example, all of them will lose; but he thinks of his neighbors' lots only as sources of light and air for his own building. If Mr. Thomas can prove that as much rentable floor space and, consequently, as large a revenue may be secured in a building occupying a smaller percentage of the lot, he has brought even immediate pecuniary advantage to the side of better housing. Continued or long-time pecuniary advantage has always been on the side of better housing.

Mr. Leavitt* has stated that he has found an increasing tendency to crowd the land. The speaker accepts Mr. Leavitt's instances, but not his conclusions. The tendency to crowd and overcrowd the land has always existed, but, although it still persists, it has been noticeably checked, not only by zoning ordinances which are being adopted all over the country, but by an informed opinion on the part of individual owners. Great estates of many acres may not be as popular now as they were some years ago, high taxes and reduced incomes have a contracting effect. Well-to-do people may be building smaller houses on small grounds, along the edges of private golf courses, and finding their opportunity for expansiveness on the golf course they own in common. This may be an indication of the growth of a community spirit that is interesting enough to warrant some study.

As for the placing of tight little rows or groups of houses among the more open buildings of New York and Philadelphia suburbs, this has seemed to some of those who have watched it to be a manifestation of the old desire to get as much as possible for as little as possible. These tight little groups, like the occasional apartment houses set in residential suburbs, owe much of their appeal to the more generous standards of their neighborhoods. Their occupants profit by what others pay for. So, of course, a considerable number of them will sell readily and to the profit of the land speculator. Their presence, however, immediately decreases the desirability of their neighborhood, and as their number increases, their appeal decreases. This is only the repetition of an old experience through which many now closely built sections of American cities have gone.

Mr. Lewis stated, there are just as bad housing conditions in sparsely settled areas of New York City as there are in the greatly crowded areas. To that the speaker takes decided exception. That there are intolerably bad housing conditions in sparsely settled areas he admits; but they differ from those of the crowded tenement districts of Manhattan in that they are superficial and easily removed. They are largely insanitary conditions, and once the public has made up its mind that it will be clean, that it will pay for water, sewers and garbage collection, they will be removed. Small-house cities like Philadelphia, for example, may, if they will, make themselves very good

* The paper by Charles W. Leavitt, M. Am. Soc. C. E., will appear in a subsequent number of *Proceedings*.

cities from the housing point of view; but when land has become overcrowded with tall barrack tenement houses, as it has in Manhattan, the evil is beyond any practical remedy. The difference is one not of degree, but of kind. Land overcrowding is the greatest and the most nearly incurable of housing ills; consequently, there cannot be as bad housing in sparsely settled areas as there is in crowded New York City.

HENRY H. CURRAN,* ESQ.—The speaker wishes to emphasize the importance of better co-operation between those who plan for cities and those who, as city officials, carry out the plans.

EDWARD S. RANKIN,† M. AM. SOC. C. E.—It may be of interest to cite an instance which occurred in Newark, N. J., during the housing shortage two or three years ago, along the line of Mr. Lewis' statement that no houses should be permitted in an industrial district. One of the largest manufacturing companies of Newark owned a tract of land bordering the meadows within what is known as the heavy industrial zone. The company proposed to build on this tract a large number of houses and brought all possible arguments to bear on the officials to allow this to be done. The tract was within reasonable distance of the plant, which was situated on the meadows, and the company proposed to sell these houses, or rent them at a reasonable cost, to its employees. After due consideration, however, the project was rejected because it did not conform to the zoning ordinance.

BENJAMIN A. HOWES,‡ M. AM. SOC. C. E.—Water supplies in practice are of such varying chemical content that no set of rules as to materials recommended for, and life of, piping can be made universal. In the case of iron and steel pipe, one water appears to form a slight but protective coating in the pipe, whereas, another forms a growing coating which finally clogs the pipe, and a third attacks the pipe and eats through it.

Chemical treatment of water to reduce its bacterial or mineral content is becoming more general. Such treatment may increase or reduce the virulence of the water's attack on the piping.

Thus, the decision as to what kind of piping is economical for houses is dependent on the character of the particular water to be used.

In the past, lead pipe was used extensively for house distribution where the water attacked iron pipe rapidly. The speaker has never known of lead poisoning resulting therefrom, because the water appears to form an insoluble coating on the inside of the lead pipe. However, the use of lead pipe in houses is seldom justified: First, because the pipe must be continuously supported to prevent sagging and consequent strain and water traps; and, second, because rats will gnaw through lead pipe for water when cut off from other safe sources. The speaker has seen instances where extensive damage to plastering and decorations resulted from rats attacking the lead distributing pipes. In another instance, the rats gnawed a large hole in the 4-in. heavy lead bend connecting the toilet bowl to the soil line, rather than go to the

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open flush tanks or toilet bowls in the rooms, or depend on rain water in the open.

Some iron and steel pipes give long service (more than thirty years), especially when galvanized. Again, wrought-iron and steel pipes on the same waters rust or clog with rust in a few years. Hot water is usually much more virulent than cold water in its attack. Such attack has been met in cases where renewal of the pipe would occasion great expense by passing the hot water and, if desirable, the cold water through storage tanks in which many sheets of thin iron or steel plates, such as metal lath, were placed to exhaust the active contents of the water before it enters the piping system. These plates were renewed from time to time and the deposited rust was removed. Rusting or corrosion seems to require, among other things, the presence of active or free oxygen. The cure in this case seems to have resulted from the removal of the oxygen in the form of rust (iron oxide).

The life of iron or steel pipe appears to depend not so much on whether it is wrought iron or steel, but on the process and completeness of manufacture. If the material is worked during manufacture into a uniform homogeneous material, it will have long life. If it is rapidly produced and carelessly worked, so that there are hard and soft spots, areas of varying carbon content, minute segregation of impurities, and the physically different cooling products of iron, there will be adjacent areas in contact, that will have different electrical potentials when in contact with natural waters, and corrosion will be prompted and the life of the pipe reduced.

Well-made brass pipe, in the speaker's experience, has been durable for both hot and cold water. Probably this is because it is so completely homogeneous. Where it is in contact, in the water, with iron or steel, such as bolts, screws, washers, and faucet fittings, there is rapid corrosion of the iron, probably by electrolytic action. The small difference, however, in present installed cost, quoted by Mr. Ham, indicates that brass pipe should be generally used for distribution of water within the house. Sometimes, there is complaint that water from such pipes has a "brassy" taste. This has been met by using "tinned" pipe. Appearance is improved, and the plumber is likely to be more careful in his threading and making up, if the pipe is also tinned outside. Economy is advanced with no apparent loss of long life if heavy, galvanized, malleable iron fittings are used instead of brass fittings, at least for the cold-water runs. Before the World War, brass pipe tinned both inside and out, cost about $5 more per 100 ft. than untinned pipe.

In the case of some New England waters which have a bad reputation for rapid attack of iron and steel pipes, very good life is obtained for the portion from the street main to the cellar, by using iron or steel pipe lined with from $\frac{1}{16}$ to $\frac{1}{8}$ in. of neat cement (Portland or natural). This lined pipe is a staple article in New England.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

WATER TRANSPORTATION*

A SYMPOSIUM

By Messrs. R. H. M. Robinson, Winthrop L. Marvin, Emory R. Johnson, and Samuel O. Dunn.

* Presented at the meeting of January 19th, 1922.

WATER TRANSPORTATION

By R. H. M. Robinson,* Esq.

There are about 60 000 000 gross tons of shipping in the world to-day; 10 000 000 tons more than there were at the outbreak of the World War, and, at least, 20 000 000 tons, the speaker estimates, more than are needed to carry on the world's commerce as it is to-day. Directly or indirectly, actually or potentially, every ton of this 60 000 000 is a competitor of every other ton. That is a distinctive characteristic of the shipping industry—the great mobility of its productive factors. Ships are spoken of as productive factors, because from them emanate the services which are the merchandise of the ship owners.

A ship built for the New York-South American service does not compete directly with ships operating in the North Atlantic, but it may force another ship out of the South American service and into the North Atlantic. For this reason, it is wrong to say that foreign tonnage does not affect conditions in the United States intercoastal trade, because a ship built in Japan for trans-Pacific service may conceivably force an American ship from the trans-Pacific into the intercoastal trade.

This kind of world-wide competition is limited to a certain extent by the fact that special types of ships are much more useful in certain trades than in others; also, by the natural preference of operators to remain in trades where they are known and where they have built up useful connections. The fact remains, however, that there is a large amount of standard type tonnage on the seas to-day, that is ready to do business wherever business may offer, and which, consequently, affects rates the world over.

To illustrate: The rates from the River Plate to the United Kingdom and the Continent, which some months ago were as low as 15/-, recently showed a marked improvement and in December, 1921, reached a level of 32/6. The effect of these high rates was to draw tonnage, that had been engaged in the less profitable Mediterranean trade, into the River Plate trade, and to induce British tonnage to load outward coal cargoes at low rates, in order to be in a position to pick up these attractive homeward freights. In this way, the improved cargo offerings at the River Plate were soon offset by increased available tonnage and the rise in rates was checked. To cite another case: The once profitable trade between the Pacific Coast ports of the United States and Europe has been brought, within a few months, to a deplorable state by the rapid introduction of additional tonnage into the service.

Thus, the fact that there is an excess of tonnage in the world to-day is significant to every ship owner. It means intense competition, scrambling for cargoes, rate-cutting, and unprofitable business, unless the situation is adjusted, either by reduction of tonnage or increase of trade. There has been wide discussion of the advisability of an international agreement for the scrapping of the present surplus of tonnage and the limitation of future building. Most ship owners, however, are holding on as long as they can in the

* Pres., American Ship and Commerce Corporation, and Acting Pres., United American Lines, Incorporated New York City.

hope that the adjustment will come through an increase of trade rather than a scrapping of tonnage.

The revival of trade will eventually come, but the speaker's views are, that it will be gradual and that some years will pass before the present amount of serviceable shipping will be given adequate employment. Meantime, the poorer ships and doubtless the weaker companies will drop out of the business, and those that stay in will do so under conditions of keenest competition and with meager profits. Of course, freight services are referred to—passenger services require special consideration.

It is certainly not out of order to consider where American shipping stands with respect to this general situation and the long competitive struggle which is ahead of American shippers. Handicaps of a serious nature are suffered. American ships cost more to build, marine wages are higher, and American experience in the business is much more limited than is the case with their principal competitors. The speaker does not intend to go fully into this subject, but there are several points in connection with the last-mentioned handicap—the more limited experience of American shipping—which will be discussed briefly.

Long experience in a business means, among other things, the establishment of helpful connections and the creation of a certain good will in the markets served. In these traffic arrangements, the newer American shipping companies sadly lacked during their efforts to get started just after the armistice. They gradually are establishing these connections at home and abroad. Too much emphasis cannot be laid on the value of good agents abroad. It is a phase of the problem that is often under-estimated. American ships need good cargoes homeward as well as outward, if they are to yield profits to their owners.

Long experience has its benefits in operating efficiency, also. Efficiency and economy are problems in every industry, and nowhere more than in shipping. It must be evident that in a business which involves such great distances as in the case with a trans-oceanic shipping company, and in which unexpected conditions are always arising, inefficiency and waste are likely to play a prominent part. Although making no claims to exceptional talent in the eradication of these evils, the speaker's study of the problem has brought to his attention certain possibilities which may be worth mentioning.

Waste may occur with respect to materials and with respect to services. Dealing first with materials, one may look at the question of fuel, which constitutes a large item in the operating cost of a steamer. A boiler may be fed to a certain point with maximum results, and fuel that is used beyond that point is sheer waste. Generally, engine-room crews are alive to this fact, but often they carelessly or willfully disregard it.

Not infrequently it is found that ships are driven at an uneconomical speed, thus uselessly increasing the fuel consumption. It is a great temptation to a captain to push the ship to her speed limit in order to make port some hours, or a day, earlier. It takes the closest kind of checking and control by headquarters to eliminate this form of waste; that is, to determine what is the

economical speed of a given vessel for a given trade under given conditions, and to enforce the proper observance of that speed.

As regards food, it is recognized that men must be well fed on shipboard, but the wastage that is sometimes encountered is prodigious. Certain of the ships of the speaker's Company, which have always been run on what was considered an economical basis, are now costing the Company no more per man per day than they were before the war, although prices are now about 50% higher. These results have been reached by giving the ships' stewards a maximum figure to which to work, and discharging him if he goes above that figure, without reasonable excuse. There have been relatively few discharges on this account. The men, moreover, are entirely satisfied with their food.

Just as a steward may waste food, so a deck or engine crew may waste paint, lubricants, and other supplies. It is a little more difficult to check up on this kind of inefficiency, but there is no excuse for allowing it to run wild. A common form of waste is that of letting machinery run down for lack of proper attention from day to day, so that in the course of time it breaks down entirely and requires extensive overhauling, and perhaps replacement of parts.

It is wasting services to carry a crew larger than is actually required. When business was good, the Company thought its crews were down to the practicable limit, but the pressure of hard times has brought about further reductions which, on some of the cargo vessels, have amounted to as many as six, seven, and eight men. This has been done, moreover, without handicapping or endangering the ship.

Services are being wasted when the crew is allowed shore leave to the extent of necessitating that shore labor be brought aboard to do their work. The American law requiring the payment of half the wages due, on demand of the seamen in port, induces the men to spend more time on shore than is good for themselves or the ship, and not infrequently leads to their being left behind, or to deliberate desertions.

The most extravagant form of waste is the wasting of the services of the ship. Several idle days at port, during which the vessel is earning nothing and is running up expenses at almost the same rate as if it was at sea, may easily destroy an otherwise fair margin of profit. Every hour counts when it comes to despatching a ship and it takes the concentrated, and one might almost say consecrated, efforts of the operating department, crew, stevedores, and all others concerned, to eliminate losses from this cause.

Recently the Operating Department of the Company worked out a plan for consolidating at one port fuel delays, which formerly had occurred at two ports. What the saving by this arrangement will amount to in the course of the year has not been calculated exactly, but it will doubtless run into many thousands of dollars.

It is self-evident that the elimination of waste in the operation of ships required a high degree of co-operation as between management and men, and there are many plans for encouraging this. There is the idea of creating a competitive spirit among the men by comparing the records of different

voyages and of the various ships of a fleet. There is the idea of a bonus granted to officers and crew when a ship makes a particularly satisfactory voyage. Sick benefits and superannuation funds also work in this direction. In a large fleet, the promotion plan may be effectively used, that is, efficiency among the men may be encouraged by holding out to them the possibility of getting higher ratings with the Company as a reward for faithful service.

It is possible to go on almost indefinitely enumerating forms of wastage which should be closely guarded against. In a business as highly competitive as shipping, inefficiency and extravagant practices cannot be tolerated; and, as has been already stated, the necessity for economy is especially strong in the case of American ship owners. The speaker does not mean to say that a sort of super-efficiency will entirely offset the handicaps which American ship-owners suffer. He is convinced that a subsidy is necessary, if American ship owners are to continue to operate under the American flag. Assuming, however, a subsidy sufficient to overcome the disadvantages growing out of peculiar American laws and conditions, ship owners still have a big problem before them in their effort to meet successfully the competition of foreign owners, because of the much longer experience of the latter in the business. The only possible way to meet this problem is to offset longer experience with more intensive study. Americans, in the engineering field particularly, have an aptitude for that sort of thing.

THE AMERICAN MERCHANT MARINE

By Winthrop L. Marvin,* Esq.

Few are the observers who would have ventured to predict in 1914 that one result of the great World War just opening would be to add 10 000 000 tons of ocean shipping to the merchant marine of the United States, thereby making this country a close rival, so far as total tonnage in concerned, of the United Kingdom which since 1860 had been the unchallenged "mistress of the seas". An expenditure of more than $3 500 000 000, the proceeds largely of several issues of Liberty bonds, has given the United States a merchant navy measured by American methods of 18 282 000 tons gross register in 1921, as compared with a total tonnage of Great Britain, measured by British methods, of 19 320 000 tons.

Of the new American merchant marine, however, this distinction must be made, that a great part of it is used in near-by home commerce, as, for example, the 2 839 000 tons of the great Northern Lakes and the mighty coastwise fleets of the Atlantic, the Pacific, and the Gulf of Mexico. However, American shipping registered for foreign commerce on June 30th, 1921, had attained a magnitude of 11 081 000 tons, an increase of 10 005 000 tons since June 30th, 1914, or a shipping twice as great as the entire great merchant fleet of the German Empire of the year when the Kaiser rashly challenged the world to arms. Of the actual sea-going vessels of the United States, in both foreign and coastwise commerce, 7 993 000 tons at the beginning of 1922 were owned by the United States Shipping Board, and 5 240 000 tons by private ship owners, firms, or corporations.

These are records of magnitude. The great merchant marine of our forefathers—the unmatched fleet of clipper ships and steam ocean liners—amounted to 5 353 000 tons in 1860. At last, after many years, American shipping has assumed "a place in the sun" comparable with other great National industries.

Of the present merchant fleet only 1 294 000 tons all told, out of a total of 18 282 000 tons, are sailing craft. The remainder, except for 1 180 000 tons of tow barges, is power driven. Allowing for the superior efficiency of the steam or gas-propelled ship—three times the efficiency of the sailing ship—the American merchant marine, measured by its capacity for transportation, has increased tenfold in sixty years. That is to say, the sea, lake, and river carriers of the United States have ten times the delivery capacity of the ships of 1860-61. This is a fact which justifies the merchant marine in holding its head reasonably high among the present-day great instrumentalities of transportation.

It speaks well for the essential vitality of the merchant shipping industry that on the coasts of the United States it has managed to increase its tonnage threefold and its actual capacity eightfold in six decades against the powerful competition of the most effective railroad systems in the world. For American coastwise ships and railroads are competitors in a considerable degree, although

* Vice-Pres. and Gen. Mgr., American Steamship Owners' Assoc., New York City.

also co-operators with each other. An excellent example of the manner in which American railroads and American ships have been made to work together is the Southern Pacific Company, with its splendid fleet of 25 steamers, of a total tonnage of 129 938, plying between New York City and the Gulf of Mexico, as an essential link in one of the greatest of the transcontinental systems. It used to be an American policy, and a wise one, to yoke ships and railroad lines in a common service, and although this policy was largely forbidden by the Panama Canal Act of 1912, it is not easy to convince thoughtful men that the United States has been the gainer thereby.

The ships need the railroads and the railroads need the ships. If there cannot be common ownership, there must be at least close harmony and co-operation. It is a fact of much significance to the railroad systems of the United States that under the American flag there now exists an immense fleet of ocean carriers, American-owned, and pledged to serve first American interests. With proper "team play" there is no reason why these American fleets may not be made dependable extensions of American railroads. Under a proper policy of National encouragement, and not discouragement, there is no reason why American shipping companies, with alert traffic organizations abroad, may not bring to American railroads a more efficient service than the foreign steamship companies have ever given, plus the vital factor of American good-will. If the plans of the present National Administration take root, no American railroad management will have a shadow of an excuse to link itself, by preferential traffic or terminal agreements, with a foreign merchant shipping, which is to say, the naval reserve, of any foreign Government.

Those interested in and of the American ocean-shipping industry bespeak from the railroads a closer understanding than has ever existed before. About one-third of the present ocean-borne tonnage is coastwise; about two-thirds normally and constantly must be working overseas. These coastwise carriers, having a natural advantage in not being compelled to maintain rights of way of stone, earth, and steel, have an important economic part to play in assembling cargoes at American ports for the overseas carriers, and in assembling and distributing goods which the railroad, in turn, must serve. One of the most powerful arguments for the strengthening particularly of the overseas merchant marine is that a more effective co-operation can be maintained by American railroads with such a merchant marine than would be possible with foreign corporations owned, controlled, and directed abroad, and maintained for the purpose of serving, primarily, alien competitive interests.

American shipping, overseas and coastwise, is suffering severely to-day from the nightmare of depression that has seized the commerce and finance of the world. Of 1 300 steel steamers of the Shipping Board, fewer than 400 are now in operation. From one-fourth to one-third of the tonnage of private ownership is unemployed. This is not strange, with the exports of the United States shrunken to one-half the volume of the exports of 1920. American overseas shipping, however, differs sharply in this point from American railroads, that while, except for the Canadian lines, the railroads are immune

from direct international competition, American ships, with their higher wage scales and living conditions, are engaged in what is unquestionably the most intensely international competition in the world.

Time is too short to go into details of the international problem of the American merchant marine; but it should be emphasized that after all this is not a complex problem, as is too often assumed. As a matter of fact, the whole proposition can be summed up in a few words: The American merchant marine in overseas trade used to be a vigorously protected National industry. As long as it was protected, even in part, by the preferential customs duties and tonnage taxes during the time of Washington, Hamilton, Jefferson, and Madison, and, afterward, by the mail subsidies of the Forties and Fifties, it flourished as incomparably the most efficient and prosperous shipping in existence. For sixty years, this American merchant marine, except the coastwise fleet, has been the one absolutely unprotected National industry, and for this reason, and no other, it had up to 1914 constantly declined.

Throughout the old years when American overseas shipping was protected, American ships conveyed on an average 80% of the imports and exports of the United States. On August 1st, 1914, American ships were conveying only about 10 per cent. All who are engaged in transportation will remember what happened in that war summer of 1914, when the German liners were withdrawn and "interned," and British, French, and Italian ships were summarily commandeered for the service of their Governments. Thanks to sixty years of neglect, there were then almost no American ships, and although the elevators and warehouses inland were full to overflowing, the railroad tracks for miles back from all the ports were choked with laden freight trains which could not be moved, because there were no ocean ships available. Commerce and agriculture for the time being were stricken with paralysis, at a cost of uncounted millions to American producers, and all for the lack of a real American merchant marine.

That experience shocked the country into a knowledge of the vital interdependence of agriculture, manufacturing, and shipping of its own. That was a lesson not easily forgotten. The President of the United States will shortly address Congress and the country in a fervent plea for National consideration of the merchant marine to take the Government out of the shipping business and to make it possible for American ship-owners and seamen to live and prosper on the routes of ocean trade, and whatever specific policy he may advise should most certainly command the eager attention of all Americans interested in trade or transportation by land or by sea.

It is not a problem now of creating a merchant marine. There is already a vast fleet in being. There is also a great corps of experienced and efficient officers and men, all the officers and a majority of the crews being American citizens. The question which the President will place before the nation is a problem of aiding and protecting this fleet in being and its personnel so that the good tonnage of the Government may be transferred to private hands and operated by private initiative and enterprise under a National policy that will give American shipping the fair chance which the tariff has brought to

manufacturing and to agriculture alike. It is the united conviction of the practical men of the American ocean shipping industry that without the equivalent of that protection which other National interests have long enjoyed, the Government-owned, war-built tonnage will remain indefinitely in Government hands, subject to the inevitable disabilities of Government control and operation, and that private shipping, now nearly one-half of the ocean-going merchant marine—and with fair play destined to be the greater half of it—will again languish and decline, because it is forced unaided to fight the competition of a kind by which no other American industry is or has been confronted.

Within a few days, American ship-owners, operators, and ship-builders of ocean tonnage have unitedly gone on record to the Government of the United States as declaring that without a vigorous National policy, direct and indirect National aid, the ships of foreign Governments, backed under every flag by some form or degree of Government assistance, and manned under wage and living conditions which Americans will not accept, will again inevitably drive American ships from the ocean and destroy at once the delivery service of the ocean commerce and the resources of a National naval reserve. Profound is the significance to the American people of the statement with which Secretary Hughes opened the Disarmament Conference: "The importance of the merchant marine is in inverse ratio to the size of naval armaments!"

In the interest of peace, the Government is going to scrap a great part of the best of the American Navy. Every obligation of National security and prosperity, however, forbids that Americans should follow up the unexampled National sacrifice already made at Washington by the scrapping of their merchant fleet.

THE MERCHANT MARINE PROBLEM

By Emory R. Johnson,* Esq.

The merchant marine has been under consideration in the United States for more than two decades. A fairly comprehensive Shipping Act was passed in 1916, and four years later a still broader Merchant Marine Act was adopted by Congress. The passage of these two laws, however, has not removed the merchant marine question from public discussion, nor has the construction of a vast tonnage of shipping for war purposes determined the status and future prospects of the merchant marine.

The purpose in this paper is to consider briefly why a merchant marine under the American flag is really needed, and whether it will be necessary to give Government aid to shipping, in order to have an efficient and adequate merchant marine. In the preamble to the Merchant Marine Act of 1920, Congress declared "that it is necessary for the National defense and for the proper growth of its foreign and domestic commerce that the United States should have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or National emergency". In spite of this declaration of Congress, however, it is by no means certain that the man on the street or even the leaders of public opinion have thought out clearly why a merchant marine is necessary, and it is even more evident that there is a lack of unanimity of opinion as to whether Government aid will be necessary for the maintenance and adequate development of merchant shipping under the flag of the United States.

Ships are built and operated primarily to carry goods and passengers. If a merchant marine is really necessary, it must be so primarily because of its relation to domestic and foreign trade. Do the people of the United States need to be served by ships under the National flag, in order to develop their foreign trade successfully and largely in competition with other great maritime and trading nations?

The major share of the tonnage transported on the high seas is carried by chartered or "tramp" vessels. These day laborers in the world's ocean-carrying business constitute more than one-half of the large merchant tonnage under the British flag; and the thousands of "tramps" under the British, Norwegian, Dutch, American, and other flags may be chartered by shippers of any and all countries. The charges made for these charter services do not depend on the flag of the vessel. Charter rates are determined by world-wide competition. The big shipper in the United States who has a full vessel cargo can charter a ship without difficulty. Such being the case, why is it necessary that American vessels be available for charter?

Although the large shipper in any country can secure foreign vessels for chartered services, it is none the less a fact that, in general, the country having the largest merchant marine has an advantage in international trade. The existence of a large tonnage of shipping under the National flag is helpful

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to the establishment and development of foreign trade. This is due largely to the fact that ships are not only a necessary facility of foreign trade, but that they are one of several inter-related agencies that co-operate in making foreign trade successful and profitable. International commerce on a large scale, under the present conditions of competition, requires a world organization of industry, trade, and shipping. This organization begins with manufacturing and includes merchandising, international banking, marine insurance, ship brokerage, freight forwarding, and the construction, ownership, and operation of vessels. When this inter-related organization has been completely developed, as it has been by the people of Great Britain, foreign commerce can be carried on under the best of conditions. If shipping under the National flag is absent from the organization, as developed by the people of any country, the organization is less effective. Shipping under the National flag and an adequate tonnage of vessels of different types are, in fact, essential parts of the trade facilities and organization with which the people of the United States will be able to extend their commerce to all sections of the world.

The foregoing statement applies to ships of all kinds, those which operate under charters as well as those managed in line services. The relation of line services to trade development is, however, even more apparent than the relation of tramp tonnage to commercial expansion. Most of the shipments of importers and exporters and the major part of the business of freight forwarders require the services of regular steamship lines. Most shipments are in small lots, and the majority of manufacturers and traders seeking to build up foreign trade require services at regular and frequent intervals, such services as are rendered by established ocean lines. British traders, large and small, have long been able to place their exports in all foreign countries and to draw their supplies from the four quarters of the globe by means of the services of regular steamship lines operated under the British flag. If the people of the United States could be sure, within a reasonable time, of ocean-line services as numerous and efficient as those of the people of Great Britain, it is quite certain that the foreign commerce of the United States would be carried on and developed under more favorable conditions than those which now prevail.

One reason for a large merchant marine under the National flag seems to be quite clear to everybody, namely, that a large and well-balanced merchant marine is a necessary auxiliary to the Navy and in times of emergency may determine naval efficiency. In times of peace, the Navy may be limited to war vessels which may require the services of a comparatively small number of auxiliary vessels, such as colliers, tankers, supply ships, and transports. When war comes, however, these auxiliary craft must be greatly increased, and vessels of 14 to 20 knots in speed, manned by an efficient personnel, immediately become a necessity to the Navy. It is estimated that in time of an emergency the present Navy of the United States would require the services of 150 such merchant vessels.

As the result of the construction of ships during the World War, there is a large tonnage of vessels under the American flag, although the number of vessels of the size and speed required for naval auxiliaries is unfortunately

only a small part of the number that would be needed by the Navy in case of a sudden emergency. As will be pointed out subsequently the present merchant marine is not well balanced, either from the standpoint of commerce or from the point of view of the Navy.

The principal powers of the world are apparently about to start on a naval holiday of ten years' duration for the purpose of economizing in expenditures for ships and naval establishments. A naval holiday is much to be desired, but instead of diminishing, it will increase the importance, from the standpoint of National defense, of maintaining a well-balanced merchant marine under the National flag.

Both for commercial and naval reasons there should be a prosperous and vigorous shipbuilding industry in the United States. During the war there was a large increase in the number and output of private shipyards in the United States, but the world-wide depression in business and the temporary surplus of shipping, as related to the reduced volume of trade, have temporarily placed American shipyards in a precarious condition. Should the present period of business depression be followed by a decline in the American merchant marine, or even by a serious postponement of the development of that marine, the shipyards in this country will suffer greatly, and probably many of them will be forced to go out of business. This would be a serious misfortune. One strong reason for adopting a policy that will assure the successful development of the merchant marine is the importance of keeping in vigorous existence the shipyards of the United States. These yards are necessary to National defense as well as to the healthy development of a merchant marine.

It is possible for an American citizen to secure a ship from a foreign builder, and register the vessel under the American flag for use in the foreign trade, but this fact does not make shipyards an unimportant part of the general organization required by the United States in building up a greater international trade. The commercial nations with which the United States must compete, Great Britain and Japan at the present time, and Germany in the future, are quite certain to have a large tonnage of shipping under their National flags. It should not be the aim of the United States to play a secondary or unimportant rôle on the high seas or in international commerce. It should rather be the policy of this country to establish, as far as practicable, all the conditions favorable to the shipping business and to the industries associated therewith.

There is another present and practical reason why it is desirable that American citizens and companies should find it profitable to own and operate vessels. The United States Government, through the Shipping Board, as a war measure, has brought into existence hundreds of vessels with a large aggregate tonnage. It is now clear to everybody that the Government cannot operate those vessels profitably. Congress has recognized this fact, and by the Merchant Marine Act of 1920 has directed the Shipping Board to sell the Government tonnage as soon as practicable and to retire at an early date from the operation of vessels.

The ships owned by the Government, that is, those that are commercially useful, ought to be purchased by Americans and operated in chartered and

line services in the foreign trade of the United States. The Shipping Board is offering its vessels for sale at competitive prices governed by world market conditions. It is to be hoped that these vessels will be bought by the people of the United States and operated successfully in foreign commerce. If the people of this country do not find it profitable to own and operate these vessels, presumably they must be sold to foreign buyers, and thus the people of the United States will be in the position of having constructed vessels that will contribute to the tonnage of shipping under foreign flags.

There is probably more unanimity of opinion as to the desirability of having a large merchant marine under the American flag than there is as to concrete measures to be taken to bring about the establishment, maintenance, and development of such a marine. From time to time before the World War, efforts were made to enact legislation providing Government aid for the merchant marine, but all these efforts failed with the exception of the enactment of the Mail Subvention Act of 1891—a very partial measure that has had comparatively little influence. To carry on the war against Germany, the United States constructed in Government yards, and purchased of private shipbuilders, a large tonnage of shipping, most of which the Government still owns. The major share of the tonnage owned by the Government, and also much of that owned by private individuals is at the present moment idle, because of the world-wide depression in business and international commerce. Again, an effort is to be made to bring about the adoption by the Federal Government of a policy of Government aid to shipping. Is such a policy necessary? Several facts indicate that Government aid in some form must be given in order to make profitable the ownership and operation of vessels under the American flag in the foreign trade. These reasons may be briefly stated as follows.

Almost without interruption, between the close of the Civil War and the beginning of the World War, the tonnage of shipping under the American flag in the foreign trade continued to decline. In 1914, less than 9% of the commerce of the United States, measured in value, was carried in ships under the American flag.

Even during 1921, at a time when private ship owners and the Government of the United States were in possession of a vast tonnage of shipping available for the service of those engaged in the foreign commerce of the United States, there was a decrease in the percentage of the total tonnage of the exports and imports of the United States carried in ships under the National flag.

The percentage of American shipping in actual service declined during 1921. The percentage of the total shipping that was idle increased, while at the same time the percentage of British shipping in actual employment increased. British ships were brought into use in increasing tonnage, while American ships were being tied up. This fact indicates clearly that it must have been more profitable to operate ships under the English flag than under the American flag in the foreign trade of the United States during 1921. The business depression could not have affected American shipping more than the shipping of Great Britain, Norway, or other foreign countries.

One of the most significant facts bearing on the question of Government aid to an American marine is the fact that the present marine under the American flag is not well balanced. There is a large tonnage of slow cargo vessels most of which were built by the Government during and after the war. On the contrary, there are only a few vessels of large size and of a speed of 14 knots or more. The importance from the naval point of view of having a relatively large number of merchant vessels of 10 000 to 15 000 tons, gross measurement, and of speed above 14 knots is very great. It is also necessary to have vessels of this type for the passenger and mail services and for the movement of high-class cargoes.

The American marine at the present time has an insufficient number of the following types of vessels:

(*a*).—Passenger and mail vessels of 15 000 gross tons and up, with speeds of 18 knots and over.

(*b*).—Passenger and cargo vessels of 10 000 to 15 000 gross tons, with speeds of 14 to 16 knots.

(*c*).—Fast cargo vessels of 9 000 dead weight tons and more, with speeds of 12 knots and over.

(*d*).—Refrigerator vessels of 8 000 to 12 000 gross tons, with speeds of 14 to 16 knots.

(*e*).—Vessels propelled by Diesel engines or by Diesel electric drive.

The significance of the foregoing statement as to the insufficiency of vessels of larger size and higher speed in the American merchant marine will be made quite clear by a brief comparison of the merchant fleets of the United States and Great Britain. In the British merchant marine, there are 632 sea-going vessels of from 2 000 to 3 000 tons gross, while in the United States marine there are 934 of these small vessels; whereas, the showing as to vessels of large size in the two fleets is directly the opposite. Great Britain has 190 merchant vessels of from 8 000 to 10 000 tons gross, while under the American flag there are only 85. In the British marine there are 138 vessels of from 10 000 to 15 000 tons gross, and in the American marine only 79. Under the British flag there are 73 vessels of 15 000 tons gross and larger, while under the American flag there are only 14.

The deficiency in the American merchant marine as regards vessels of the higher types is indicated by the fact that in both the British and American fleets there are practically the same number of vessels capable of speeds of less than 12 knots, 2 556 under the British flag and 2 567 under the American flag. As regards vessels of a speed of 12 knots and more, there are 985 under the British flag and only 218 under the flag of the United States. Of vessels of speeds of 14 to 16 knots, there are 221 British and 53 American; of speed of 16 to 18 knots, 92 British and 38 American; of a speed of 18 knots and more, 21 British and 7 American.

In another particular the merchant marine of the United States is unbalanced. The large refrigerator ship which makes possible the shipment of perishable commodities from any point of production to any part of the world, has come to play an important part in international trade. On June

30th, 1921, the British merchant marine contained 233 refrigerator vessels, with a gross tonnage of 2 000 000, while, at the same time, there were only 44 such vessels under the American flag, and their gross tonnage was only 220 000. In other words, the commerce of Great Britain was served by nearly ten times the tonnage of refrigerator vessels.

Argument is not necessary to prove that the efficiency of the American marine in competition with the merchant shipping of other countries depends on the construction and addition to the merchant fleet of the larger types of vessels of higher speeds. Moreover, the assistance which the merchant marine may render to the Navy in times of emergency depends on the number of ships of speeds of 14 knots and more and relatively large capacities.

In tonnage of vessels having oil-burning engines, the United States is in the lead, as a result of the equipment of a large part of the Government-built vessels with engines using oil for fuel. These are steam engines and mainly reciprocating engines. Experts believe that the most economical and efficient engines of the future will be those of the Diesel type. The fuel consumed is much less and the sailing radius is much greater. The initial cost is also higher. It is important that ship owners should be encouraged to convert some of their steamships into Diesel-engined vessels, and that those who order vessels in the future should be able to order an increasing percentage of new tonnage equipped with Diesel engines.

It can hardly be hoped that American citizens and American companies will find it profitable in the near future to construct, own, and operate vessels of large size and of relatively high speed without some form of Government aid, indirect or direct. The capital cost of such ships in American yards in the future will almost certainly be higher than in foreign yards. How much higher, it is not easy to determine.

Some significant facts in regard to the higher capital cost of American ships as compared with those built in foreign yards are fairly definite. Before the World War, the average cost of vessels was probably not less than 25% greater in American than in foreign yards. In many cases, the cost in America was 40% greater than in other countries. At the present time, very few bids are being requested by prospective purchasers of ships. A careful estimate has recently been made, however, as to the comparative costs of like vessels in American and foreign yards at the present time, and the conclusion has been reached that the cost in this country would be about 18 or 20% higher than in other countries. This differential, moreover, is not likely to decrease in the near future.

The man or the company who buys a ship in an American yard and operates it under the flag of the United States has two handicaps to overcome in competition with those who purchase ships in foreign yards and operate them under foreign flags. These handicaps are capital costs, or overhead, and operating expenses. Capital charges including interest, depreciation, and insurance amount to 17 or 17½% per annum on the investment in the ship. Thus, if a large freight vessel costs only $100 000 more when purchased in an American yard than when bought of a foreign builder, the owner has an annual excess capital cost of $17 000 or $17 500.

The operating expenses for ships under the American flag are unquestionably higher than for vessels under foreign flags. This is due mainly to differences in wages. For a standard freight vessel of 8 800 tons dead weight, the wages paid on the American ship during 1921 apparently averaged about $1 100 more than the wages paid on British ships. As compared with Norwegian vessels, the American wage handicap was even greater. There has recently been a readjustment of seamen's wages both in Great Britain and in the United States, and the difference in wages has been reduced, but it is still large, amounting to not less than $600 per month for a standard freight vessel. It also costs the American ship somewhat more for subsistence for its crew, and it is probable that the regulations of the United States Government as to inspections are more than those of foreign countries.

The United States Shipping Board is preparing a report which will set forth in detail the relative costs of American-built and foreign-built ships and the relative expenses of operating vessels under the American and foreign flags. The detailed results of this investigation are not yet available, but the figures will undoubtedly show that in the case of vessels of all classes, ordinary freight carriers, combination freight and passenger ships, and high-class passenger and mail vessels, the capital costs and the operating expenses are higher for the American than for the foreign ship owner and operator.

The inevitable conclusion is that if the American people are to have a large merchant marine in the future—a marine that can be operated profitably, and that will be progressively efficient—it will be necessary for the United States Government to give at least temporary aid to shipping.

WATER TRANSPORTATION IN ITS RELATION TO THE RAILWAYS

By Samuel O. Dunn,* Esq.

The speaker is glad that the subject assigned to him is that of "Water Transportation in Its Relation to the Railways" instead of that of "Water *versus* Rail Transportation", which appears on the programs of many meetings and conventions. The competition that has existed, or that many think should exist, between carriers by rail and by water has been emphasized too much in the United States. The co-ordination of rail and water service of which there should be more, has been emphasized too little.

The policy of the Government in dealing with the rail and water carriers should have two purposes, both of great importance: First, to influence traffic to move by those routes over which the total cost incurred will be the least, considering the character of the service; and, second, to promote development of railways and shipping which will make them adequate to National needs in both peace and war. The speaker has referred to needs in war, because they should be given great consideration in shaping American marine policy. Wars are likely to come again in spite of all efforts to prevent them. The more that naval armaments are curtailed, the more vital will be the part played in any future wars by merchant vessels that can be converted into fighting ships. American business needs in time of peace and certain military needs in case of war combine to make a conclusive argument for a public policy that will promote the development of an American merchant marine as large as that of any other country.

The conditions are and will be such that the Government cannot, in some cases, carry out a policy that will both influence traffic to move by the cheapest route and at the same time foster the development of the merchant marine. There will be cases, for example, where it will be cheaper to ship American products overseas in foreign rather than in American vessels. The object should be to secure the cheapest transportation for American goods, that is consistent with the upbuilding of an adequate American merchant marine, as well as an adequate railway system.

The water carriers with which the railways have relations may be roughly divided into four classes.

The first class is composed of ocean-going vessels carrying goods between American ports and those of other countries. There is traffic which moves entirely by ship between the Pacific ports and Europe. There is traffic which moves entirely by ship between the Atlantic ports and the Orient. This traffic is handled partly by American, but mainly by foreign, ships. Directly or indirectly, the trans-continental railways compete for it. In the past they have made many rates intended to cause it to move partly by land and partly by water rather than entirely by water. For example, to capture traffic which otherwise would have moved by boat from the Atlantic seaboard, through the Suez Canal to the Orient, the railroads formerly made rates to the Pacific

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Coast, that were much lower on export than on domestic business and changed them as often as was necessary to get their share of the business. Public regulation required, however, that they should publish these rates. This rendered it impossible to make rapid changes in them, and the roads were also required not to go beyond certain limits in reducing them below their domestic rates. In consequence, a large part of this business was lost by the railroads.

Of course, however, the usual relationship between the railways and vessels in trans-oceanic service is that of connections rather than competitors. This is so true that there are some notable examples of trans-oceanic steamship lines being owned and operated by railway companies as through routes in connection with their railway lines. The Canadian Pacific operates vessels on both the Atlantic and the Pacific. The Great Northern under the management of the late James J. Hill, F. Am. Soc. C. E., established a steamship line on the Pacific to the Orient. The Southern Pacific owned the Pacific Mail Steamship Company and rendered service across the Pacific Ocean in connection with its rail lines. There have been other examples of the same kind, but, at present, practically none of the railways of the United States is operating boats owned by them in trans-oceanic service. The operation of trans-oceanic steamship lines by railway companies has benefited Canada, and probably would benefit the United States, but the American policy of regulation of railways discourages it. Although the American policy of regulation of railways discourages them from owning and operating trans-oceanic steamship lines, an attempt is now being made to force them to favor American vessels in handling export and import freight. The two policies seem inconsistent.

The Government, undoubtedly, should use its influence to bring about every form of co-ordination between the service and rate-making of the railways and the merchant marine of the United States. Neither morally nor economically, however, would it be justified in requiring that the railways establish rates and service in connection with steamship lines, which would cause losses to the railways. It is no part of the duty of the railways, directly or indirectly, to subsidize the steamship lines any more than it is a part of the duty of the steamship lines to subsidize the railways. The American merchant marine should be built up for the benefit of the entire nation and, therefore, insofar as it must be subsidized the entire burden of the subsidies should be borne by the public through the Government. If the railways are to be required to favor American ships in the matter of contract relations, interchange of traffic, or otherwise, it should be done in a way which will be helpful to the merchant marine without being injurious to the railways which have just as good a claim to fair and helpful treatment from the Government as the merchant marine.

The laws give American ships a monopoly of the coastwise trade. Ocean transportation is so much cheaper than rail transportation, where the distances by rail and water are anywhere near the same, that it is impossible for the railways to compete with it. Even where the distance by water is much greater than by rail, as it is by the Panama Canal route between the Atlantic and Pacific Coasts, the railways can hardly hope to compete for traffic that

originates on or near one coast and is destined for points on or near the other coast. The conditions are different when traffic originates in, or is destined to, points in the interior and, therefore, must be handled either partly by rail and partly by water, or entirely by rail, and this is true of most of the traffic for which the railways compete with the Panama Canal route.

The question of what relations should be established between the railways and coastwise vessels using the Panama Canal is still the subject of much controversy. The railways are prohibited from owning vessels operating through the Canal. The vessels are now required to pay tolls, but in spite of this are taking an increasing amount of the competitive traffic away from the railways. Attempts are being made to secure the abolition of the Canal tolls, which would give the vessels an increased advantage. Meantime, the railways are asking the Interstate Commerce Commission to allow them to reduce their rates to the Pacific Coast without making corresponding reductions in their rates to interior points, in order that they may meet the competition of the vessels to points on the coast without, at the same time, reducing their earnings on traffic going to the interior.

Here, the problem of establishing proper relations between the railways and water carriers is found in its most complex and difficult form. It cannot be solved correctly merely by considering what is to the interest of the steamships or the railway lines. It can be solved correctly only by considering what is to the interest of the nation as a whole. Americans should spare no reasonable effort to build up their merchant marine. That is in the National interest. At the same time, they should not in order to build up the merchant marine, adopt a policy which will tend to tear down those railways which seek to share in this traffic.

The competition which presents the problem is, it should be noted, not between means of transportation owned on the one side by Americans and on the other side by foreigners. It is between two kinds of transportation agencies both of which have been provided by American capital and both of which are equally entitled to be fostered, or at least not injured, by the American Government. The speaker feels so strongly in favor of the upbuilding of the American merchant marine that if it was necessary to subsidize it to enable it to compete successfully with the merchant marines of other countries for American commerce and that of the rest of the world, he is in favor of subsidizing it from the public treasury as much as may be necessary. Other nations do this, and Americans cannot safely refrain from doing so while they do it.

However, when the question presented is one arising from competition between American railways and American ships, the latter operating through a canal built for taxes paid by the entire American people, it seems to the speaker that such influence as the Government may exert should be used to cause the traffic to move by the cheapest route, differences of service being considered. What, however, is the real measure of the relative cheapness of rival routes? It is not merely the rates actually charged the shipper at any given time. If, for example, the coastwise vessels were exempted from tolls and reduced their rates to the shipper correspondingly, this would not mean

that the cost of transportation by the Canal route had been reduced. It would simply mean that the public was paying in taxes part of the cost which the shipper before had paid in the rates. The true cost of transportation by any route, rail or water, is the rate for which the carrier rendering the service can reasonably afford to haul the shipment without receiving any contribution toward payment of the cost of hauling it, except the rate charged. This is an abstract statement, but the speaker will use the very question under consideration to illustrate concretely what he means by it. The railways to the Pacific Coast have no source of income but their rates which, as a whole, must cover all their outgo. They can better afford to reduce their rates on this trans-continental traffic below the average rates they obtain on all their traffic and thereby get some of this trans-continental traffic than go without it entirely. There is, however, a limit below which the railways could not reduce their rates on trans-continental traffic without making the earnings from it less than the out of pocket expense incurred in handling it. The railways can be trusted, because of their own self-interest, to let the traffic go entirely rather than reduce the rates to a point where they will be actually unremunerative. The speaker maintains that if the coastwise vessels cannot pay tolls which will contribute reasonably toward the interest, maintenance, and operating charges of the Canal, and at the same time operate at a profit on rates low enough to meet the rates on trans-continental traffic that the railways find they can better afford to make than give up the business, then the rail route is actually cheaper than the water route and the business ought to move over it.

As a matter of fact, there is no doubt in my mind that the coastwise vessels always will be able to pay substantial tolls and at the same time carry most of the trans-continental traffic. To exempt them from the tolls and at the same time prohibit the railways from making lower rates to the coast than to the interior would be to drive the railways entirely out of the trans-continental business and force them to get all their earnings from traffic for which they do not compete with the steamship lines.

The relations of the railways to water carriers on the Great Lakes are like their relations to most coastwise carriers. The cost of transportation on the Great Lakes is so much less than it is by rail for traffic that can be handled entirely or almost entirely by water that the railways cannot compete for this traffic. The water carriers have a virtual monopoly of the transportation of coal to the Northwest from the Pennsylvania and West Virginia fields and of ore from the Northwest, the railways simply serving as feeders to them. The lakes are closed to navigation in the winter, however. This gives the railways, which can operate the entire year, an advantage in respect to the relative costs of rendering service that they otherwise would not have. Furthermore, the traffic between the North Atlantic seaboard and Chicago must be transferred *en route* if it moves part way over the Great Lakes. Finally, the railways are better able than most of the lake carriers to give prompt service and to maintain agencies throughout the country for the solicitation of business. Consequently, the all-rail routes between Chicago and the Atlantic seaboard are able to compete for most kinds of business with

the rail and lake routes. Formerly, several railways owned and operated boat lines on the Great Lakes, which formed direct through routes in connection with the eastern rail lines. Legislation intended to increase competition between the lake lines and the railways prohibited this railway ownership of boat lines except when authorized by the Interstate Commerce Commission. The result was that most of the railways were forced to sell their boat lines and the service on the lakes was seriously reduced. The legislation, instead of conferring a public benefit, accomplished a public injury, as such legislation not infrequently does.

The only remaining waterways with which the railways have any relations are canals and improved rivers. The Government has spent large sums of money in trying to develop canals and rivers which could compete with the railways. It has passed legislation to prevent the railways from reducing rates solely to kill water competition and later increasing them; but while the traffic of the railways has continued to increase, the traffic of most canals and rivers has continued to dwindle. Probably one of the main reasons for this is that the Government has wasted its energies and money by spending them on many projects instead of by concentrating on a few of the most promising. Recently, the Government has been making an experiment with inland water service which is of real interest and importance. This is on the Mississippi and Warrior Rivers. It has at public expense provided improved towboats and barges and has built new water terminals at several points. On their face, the results thus far obtained are not highly encouraging. In the year ended June 30th, 1921, the operating deficit incurred on the Mississippi River section was \$503 000 and on the Warrior River section \$480 000. On the Mississippi River the average revenue from each ton transported was \$4.39, whereas the average operating expense for each ton transported was \$6.56. On the Warrior River section the average revenue for each ton transported was \$1.86, and the average operating expense for each ton was \$4.11. The report shows, however, that in the three months, April, May, and June, an actual net profit of almost \$23 000 was earned on the Mississippi River section.

Although the speaker has said the results thus far obtained from this ambitious project are far from satisfactory, he believes that the Government should be encouraged to continue the experiment and that in this and all other cases the railways should freely co-operate with the water carriers in the interchange of traffic and refrain from making rates intended mainly to drive them out of business. There has been much discussion in this country of the relative costs and advantages of rail and water transportation. This discussion insofar as it has related to rail transportation *versus* canal and river transportation has been peculiarly barren, because never has canal and river transportation been tested under such conditions with respect to depth of waterways and character of towboats, barges, and terminals as to enable one to judge intelligently of the relative costs of modern inland water transportation and modern rail transportation under American conditions. Personally the speaker does not believe that inland water carriers, except on the Great Lakes, can ever compete successfully with the railways of the United

States if the character of the service as well as all the costs incurred in rendering the service are considered. In the total cost of water transportation is included, not only the cost of maintaining and operating the boats, but also the cost of maintaining the waterway and interest on the investment made in improving it. No comparison of the cost of water transportation with the cost of rail transportation is fair or reasonable, which does not include these items. More real evidence is needed regarding the actual cost of rail and inland water transportation from which to draw final conclusions.

Perhaps it will not be inappropriate to suggest in closing that there is no other organization in this country that is so competent to determine where rail transportation can be rendered at less economic cost than water transportation and where water transportation can be rendered at less economic cost than rail transportation as this Society. May the speaker venture to add that public men and public opinion need guidance in solving this and all other great transportation problems and that the competency of engineers in this respect carries with it a correlative duty.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

RAILROAD TRANSPORTATION*

A SYMPOSIUM

By Messrs. Howard Elliott, W. N. Doak, and F. A. Molitor.

With Discussion by George W. Simmons, Esq.

* Presented at the meeting of January 19th, 1922.

RAILROAD TRANSPORTATION

By Howard Elliott,* Affiliate, Am. Soc. C. E.

It was the speaker's good fortune, from 1903 to 1913, to be President of the Northern Pacific Railway Company.

In that decade the owners and directors spent more than $100 000 000 in improving the property in a physical way, and a large amount of work was done in making the Northern Pacific a transportation machine that could produce a maximum of transportation units with a minimum expenditure of physical energy. This was for the ultimate purpose of giving to the growing communities between Lake Superior and the Pacific Ocean, good transportation at the lowest practicable rates consistent with a fair return on the fair value of the plant.

In that interesting work the speaker had the assistance, as Chief Engineer, first of E. J. Pearson, M. Am. Soc. C. E., resourceful in design and experienced in the use of modern railroad facilities, and who is now President of the New York, New Haven, and Hartford Railroad Company, and, later, of W. L. Darling, M. Am. Soc. C. E., a past master of railroad engineering problems.

The Stockwood Fill on the Northern Pacific.

One interesting piece of work was the revision of the line and grade on the Northern Pacific in order that heavy tonnage trains could be moved from the Red River Valley over the Divide into the Mississippi Valley. An east-bound grade of 0.30% was decided upon in place of the existing maximum of 1½ per cent. To accomplish this required an embankment 7.3 miles long having a maximum height of 49 ft., and a total yardage of 5 155 694, of which 4 067 844 cu. yd. are above the plane of the original ground line and 1 087 850 cu. yd. are below that plane.

After the work was started, it was discovered that the bed of a prehistoric lake was beneath part of the heavy fill, the old lake bed being filled with a sedimentary deposit of sand, saturated with water, for about 20 ft., underlaid by soft blue and yellow clay. The result was that the heavy fill broke through the surface and the continuity of the 0.30% grade line was broken, forcing the introduction of a short piece of 1% grade, which, however, does not limit east-bound train tonnage, except in bad weather, when helping engines have to be used. This work was begun in March, 1906, and completed in December, 1909. For ten years there has been little further subsidence, and it is possible that in due time the entire embankment can be brought up to the original 0.30% grade.

The Line Between Vancouver, Wash., and Portland, Ore.

Another interesting work with which it was the speaker's privilege to be associated, was the building of the Spokane, Portland and Seattle Railway, which has a 0.40% grade between Spokane and the Snake River, and 0.20% grade along the Snake and Columbia Rivers to Portland, thus making a fine

* Chairman, Executive Committee, Northern Pacific Ry. Co., New York City.

line for the development of the Inland Empire and the Columbia River Basin, capable of being operated cheaply when any substantial tonnage is moving. The entire line along the Columbia and Snake Rivers and from the Snake River to Spokane, Wash., is most interesting from an engineering (as well as from a commercial) standpoint, and has much heavy rock work through and around basaltic cliffs and many heavy fills across "coulees".

The Spokane, Portland and Seattle Railway Company is owned jointly by the Northern Pacific Railway Company and the Great Northern Railway Company and uses certain parts of the Northern Pacific, the bridge over the Columbia River, at Pasco, and the entrance to Portland on the west bank of the Willamette River; as well as the old Northern Pacific main line to Goble, Ore., where connection is made with the Astoria and Columbia River Railroad, purchased by the Spokane, Portland and Seattle, thus forming a low-grade line between Spokane and Astoria at the mouth of the Columbia. There is also a branch, 156 miles long, to Central Oregon. The Northern Pacific Company, with its main north and south line between Portland and Tacoma and Seattle, joined the Spokane, Portland and Seattle (of which it is a one-half owner) in creating a remarkable piece of railroad from the north side of the Columbia River at Vancouver, Wash., to the west bank of the Willamette River at Willbridge, in North Portland, Ore.

This line is made up of the bridge over the Columbia River, Hayden Island, and Oregon Slough; 6 467 ft. of bridge, of which 2 194 ft. are girder spans over Hayden Island and 4 273 ft. truss spans over the two channels, with draw spans of 467 ft. and 333 ft., respectively. The maximum depth of the foundation below low water is 80 ft. and below the base of rail 126 ft. About 3 miles of road have been constructed across the St. John Peninsula, in Oregon, in order to reach the Willamette River which has a heavy bluff on the east side. In order to maintain the grade line, this bluff had to be cut and 2 357 000 cu. yd. of material were taken out. Then, the Willamette River Bridge, 1 767 ft. long, with a draw span, 521 ft. long was built, the largest double-track draw span in the world at that time. The maximum depth of the foundation below low water is 86 ft., and below base of rail 148 ft.

There were used in the construction of the two bridges:

Masonry and concrete....................	79 012	cu. yd.
Steel superstructure.....................	22 175	tons
Timber in foundation....................	6 927 000	ft. B. M.
Piling	296 860	lin. ft.

and the two bridges cost $1 160 000, a sum far less than they would cost to-day.

Work was begun on the foundations for the Columbia River Bridge on February 8th, 1906, and the superstructure was completed on February 26th, 1908. Work on the Willamette River Bridge was begun on August 11th, 1906, and the first train between Portland and Vancouver was moved on November 5th, 1908, and regular passenger service began on November 17th, 1908. The bridges and the connecting tracks are double track, and are now being used by the Northern Pacific, the Spokane, Portland and Seattle, the Great Northern,

and the Oregon-Washington Railroad and Navigation Company of the Union Pacific System. Mr. Darling was Chief Engineer of the Northern Pacific and the Spokane, Portland and Seattle at that time, and Ralph Modjeski, M. Am. Soc. C. E., was in charge of these two great bridges.

As time goes on, this Spokane, Portland and Seattle line to Astoria, and this entrance to Portland, will play a more and more important part in the development, commercially and socially, of that interesting part of the Northwest between Portland and Bend, Ore., on the south, Astoria on the west, Vancouver, B. C., Canada, on the north, and east into the Inland Empire and the Columbia and Snake River Basins.

Work on the New Haven.

On the New York, New Haven, and Hartford Railroad, it became absolutely necessary to add to the capacity of that property if it was to serve the large tributary population. Mr. Pearson was asked to associate himself with the property and, with him, plans were developed for the work that is gradually being finished under his direction. This addition increases the ability of the property to handle its heavy freight tonnage and numerous passenger trains and reduces the cost per unit of transportation produced. Two important pieces of work are the large freight yards at New Haven, Conn., and Providence, R. I.

Importance of the Engineer to Transportation.

Some of these things are mentioned to emphasize the great importance of the engineer in the transportation problem of the country, not only in creating the original transportation machine, but in perfecting it so that there will be the maximum output at a minimum cost in these days of complications, high wages, and other costs, affecting the administration of any industrial plant. Also, to show how much benefit the speaker's education as an engineer and his association with engineers has been in his work in the railroad world.

Railroad Transportation.

The speaker has been asked to say something about "Railroad Transportation", which is so vital to the present and future development of the United States and its people, agriculturally, industrially, financially, and socially. Without easy means of communication, it is obvious that the highest development of our wonderful resources and the consequent improvement of living conditions cannot be obtained.

Record of Half a Century.

Let us examine briefly the development of the railroad system in a half century—a development made possible by men of imagination, vision, and courage; by financiers and investors who took chances; and last, but not least, by engineers who have been able to carry into effect the plans and purposes of the other two groups.

TABLE 1.—MILES OF STEAM ROADS—SINGLE-TRACK—OWNED.

	United States.	Eastern District.	Southern District.	Western District.
1870 (June 30th)	53 399	27 068	11 888	14 443
1920 (December 31st)	253 708	61 296	51 274	141 138
Percentage of increase	375	126	331	877
Population:				
1870 (June 1st)	38 558 371	21 693 654	7 899 435	8 965 282
1920 (January 1st)	105 710 620	51 565 264	18 356 714	35 788 642
Percentage of increase	174	138	132	299

TABLE 2.—URBAN* AND RURAL POPULATION.

Year.	Urban.	Rural.	Percentage of urban.
1880	14 358 167	35 797 616	28.6
1890	22 298 359	40 649 355	35.4
1900	30 380 433	45 614 142	40.0
1910	42 166 120	49 806 146	45.8
1920	54 304 603	51 406 017	51.4

* Urban population comprises that population residing in cities and other incorporated places of 2 500 inhabitants or more, and in unincorporated towns of 2 500 or more in Massachusetts, New Hampshire, and Rhode Island.

It is interesting to note that the railroad mileage has increased twice as fast as the population (mileage 375%; population 174%). In the great empire west of the Mississippi, mileage has increased 877%, and the population 299 per cent. This indicates clearly that the men of courage and vision, the men with ability to raise money, the engineers with ability to design and construct have done a great work in providing the present marvellous transportation machine that is so essential if the 107 000 000 people who are crowding too much into cities and away from the country, are to be sheltered, fed, clothed, kept warm, and safeguarded in their various occupations and in their homes. These men ought to receive commendation and thanks for what they have done and made possible for the country, and the great transportation machine ought to be allowed a living and be encouraged to expand.

Unfortunately, for the future growth of the United States, there is too great a tendency on the part of the public and the lawmakers to see only the minor mistakes incident to the creation and operation of this great transportation engine, which is performing such prodigious work for all (hampered by many laws), and failing to appreciate the whole wonderful work and what the Nation would be without it. They hold the "penny" of failure so close to their eyes that they do not always see the "twenty-dollar gold piece" of accomplishment.

GROWTH OF THE UNITED STATES.

What have the American people done in 50 years? Marvellous accomplishments, made possible by the wonderful transportation system in moving food, fuel, raw materials, finished products, and people in vast quantities and over great distances.

TABLE 3.—STATISTICS OF RECORD OF PROGRESS OF THE UNITED STATES, 1870 and 1920.*

Item.	1870.		1920.	Ratio. 1870:1920.
Wealth	$30 068 518 000		† $300 000 000 000	1:10
Wealth per capita	779.83		† 2 839	1: 3.6
Public debt, less cash in Treasury (July 1st)	2 331 169 956		24 330 889 731	1:10
Public debt, per capita	60.46		228.63	1: 3.8
Interest bearing debt (July 1st)	2 046 455 722		24 061 095 361	1:12
Annual interest charge‡	118 784 960		1 016 592 219	1: 9
Interest per capita‡	3.08		9.55	1: 3.1
Total money in circulation (July 1st)	676 284 427		6 087 555 087	1: 9
Total money in circulation per capita (July 1st)	17.51		57.21	1: 3.3
Total value farm animals	1 518 465 000		8 507 145 000	1: 5.6
Production of Principal Commodities:				
Wool (pounds)‡	162 000 000		308 507 000	1: 1.9
Wheat (bushels)‡	235 884 700		787 128 000	1: 3.3
Corn (bushels)‡	1 094 255 000		3 232 367 000	1: 3
Cotton (500-lb. bales, gross weight)	4 024 527		12 987 000	1: 3.2
Rice (pounds)	54 888 880		§ 1 491 944 444	1:27
Sugar (beet) (pounds)	‖ 806 000		1 452 902 000	1:1803
Sugar (cane) (pounds)	87 043 000		244 250 000	1: 2.8
Gold (dollars)‡	50 000 000		‖ 49 509 400	1: 1
Silver (dollars—commercial value)‡	16 434 000		57 420 325	1: 3.9
Aluminum (pounds)‡	....		41 375 000	......
Cement (barrels)‡	....		96 944 000	......
Coal (long tons)‡	29 496 054		576 431 250	1:20
Copper (long tons)‡	12 600		539 759	1:43
Lead (short tons)‡	17 830		476 849	1:27
Mineral waters (gallons sold)‡	....		40 000 000	......
Natural gas (dollars)	....	(1919)	162 000 000	......
Petroleum (gallons)‡	220 951 290		18 622 884 000	1:84
Phosphate rock (long tons marketed)	....		4 103 982	......
Iron ore (long tons)‡	3 031 891		69 558 000	1:23
Pig iron (long tons)‡	1 665 179		36 925 987	1:22
Steel (long tons)‡	68 750	(1919)	34 671 232	1:504
Total minerals (dollars)†	218 598 994		6 707 000 000	1:31
Manufacturing Industries of United States:				
Cost of material used (1860)	$1 031 605 092	(1914)	14 368 088 831	1:14
Value of products (1860)	1 885 861 676	"	24 246 434 724	1:13
Manufactures of cotton (value) (1860)	115 681 774	"	701 300 933	1: 6.1
Manufactures of wool (value) (1860)	73 454 000	"	464 249 813	1: 6.3
Manufactures of silk (value) (1860)	6 607 771	"	254 011 257	1:38
Total expenses public schools (1870)	63 396 666	(1918)	763 678 089	1:12

* "Statistical Abstract of the United States", 1920.

† Estimated.

‡ Calendar years.

§ Figures include only about 45% of California crops.

‖ Approximate.

The population, production, wealth, and comforts have increased. Schools, colleges, libraries, hospitals, and attention to the sick and poor are all on a much larger and better basis, due to the growth of the country and the use of its resources; and in all this, the railroads were and are absolutely essential, but they have not prospered accordingly.

RAILROAD TRANSPORTATION FURNISHED.

This development has been possible by the movement of an enormous number of tons of freight and passengers, as shown by Table 4.

This development has furnished sufficient passenger transportation, in a reasonably good year, to give every man, woman, and child a trip of more than 350 miles, and enough freight transportation to haul between 3 000 and 4 000

tons 1 mile for each, which is equivalent to handling more than 10 tons of freight 1 mile every day in the year for every man, woman, and child in the United States.

TABLE 4.—PRODUCTION AND CONSUMPTION OF TRANSPORTATION.

Fiscal year.	Population.	Tons per mile.	Passengers per mile.	Tons per mile per person.	Passengers per mile per person.
1900.....	76 129 408	141 599 157 270	16 039 007 217	1 860	210.7
1905.....	84 219 378	186 463 109 510	23 800 149 436	2 214	282.6
1910.....	92 267 080	255 016 910 451	32 338 496 329	2 764	350.5
1915.....	99 340 635	277 135 000 000	32 475 000 000	2 790	326.9
1917.....	102 172 845	*398 263 061 787	*40 099 757 819	*3 899	*392.5
1918.....	103 587 955	*408 778 061 079	*43 212 458 079	*3 946	*417.1
1919.....	105 003 065	*367 161 370 571	*46 838 165 980	*3 497	*446.1
1920	106 418 175	*413 675 000 000	*47 966 000 000	*3 887	*450.7
1921†....	107 833 284	*324 000 000 000	*37 700 000 000	*3 005	*349.6

* Calendar year.
† Estimated.

SAFETY.

Thirty years ago, the average traveler took eight railroad trips per year, and now he takes twelve trips. Then, he averaged 24 miles per trip, and now 38 miles. Notwithstanding that he rides more frequently and greater distances than formerly, yet the danger to life is far less than it used to be.

In 1920 the railroads of the United States carried about 1 300 000 000 passengers, with 1 killed for every 5 673 000 carried. In a total of 472 000 000 people carried in 1889, the death rate was 1 in 1 523 000. The danger to life of railroad travelers in 1920 was, therefore, less than one-third of what it was in 1889, most of the reduction accruing since 1907. To be sure, there have been years when the proportions varied, but the general trend throughout the whole period has been decidedly toward the increasing safety of the traveling public.

TABLE 5.

Year ended June 30th.	Net railway operating income.	Property investment.	Percentage of rate of return.
1911....................	$ 724 184 708	$14 246 167 475	5.08
1912....................	708 484 383	14 632 497 022	4.84
1913....................	787 610 435	15 284 763 489	5.15
1914....................	661 018 147	15 842 127 273	5.17
1915..................	683 104 833	16 257 146 632	4.20
1916....................	984 872 959	16 688 440 056	5.90
Year ended Dec. 31st:			
1916....................	1 040 084 517	16 884 440 038	6.16
1917....................	934 068 770	17 762 152 127	5.26
1918....................	638 568 603	18 213 629 613	3.51
1919....................	454 984 953	18 529 749 653	2.46
1920....................	21 661 782	19 134 000 000	0.11
1921*.......	542 409 582	19 694 622 226	2.75

* Twelve months ended September 30th, 1921. The returns for this period include fifteen large switching and terminal companies.

The Inadequate Pay of the Railroads.

As an abstract question, any fair-minded man will say that "the laborer is worthy of his hire", and that the railroad should be compensated justly and even generously for the service rendered, so as to provide for the future when more and better transportation will be needed. What has been the result? In Table 5 is shown the rate of return to the railroads for the period 1911-21, which return is wholly inadequate, if private ownership is to be sustained and if Government ownership is to be avoided.

At present, the country and the railroads are in some distress; agriculture is in trouble, industry is slack, and business is poor. The railroads realize this, but those who are now advocating that one way to bring about a resumption of business activity is to reduce the railroad income still further should be careful.

Economic Adjustment, Inflation, and Deflation.

The speaker would like to say a word about "deflation" and "inflation". During the World War, agriculture and industry generally, and wages, were more or less inflated, and much higher prices were received for food, fuel, and articles produced, than prior to the war, and wages were increased. Farmers and farm plants improved their condition very much, and agricultural lands were sold at never before dreamed of prices. Securities representing manufacturing plants were much higher in value and in price. A great many manufacturing enterprises were able to put their prices during the war on such a basis that there were large profits, either in money or in additions to their plants and facilities, so that they are now in a much better position than before the war.

Every one will admit that there was a period of inflation and of considerable prosperity for the farmer, the manufacturer, and the wage earner. There was not, however, for the railroads. They received a scanty living through payments from the Government, in order to keep them going; but, unfortunately, their properties were returned to them deteriorated as to their physical condition, demoralized as to their personnel, and with many new and difficult methods of management and high wage costs imposed.

These conditions, growing out of war and Governmental control, are being corrected slowly by the hardest kind of work between the managements and the men, and with the Governmental agencies, which, under the Transportation Act, have the final power in each of these matters.

All Must Share the Burden of Deflation.

Deflation is taking place to-day in many directions, and all must bear part of the burden. The farmer has felt the full force of this, and from the prosperous condition in which he lived during the war, he has had to come down a long way. This naturally hurts him, and he, not unnaturally, looks around for relief.

The railroad officials believe that agriculture is one of the fundamental industries in the United States, and that they should help it by a moderate reduction in rates as one step in trying to better the existing situation, not

because they can afford to do it out of their present returns, but on the ground of helping out.

Manufacturing enterprises are also deflating, and the same may be said about the jobbing and distributing business. It is a slow and difficult process, but, again, these two classes of human industry had, during the war period, the chance for great prosperity, large profits, and great additions to their plants, and many of them availed themselves of that opportunity, but the railroads did not have that chance.

What is generally described as "labor" has already been hurt by unemployment and by some reduction in wages, which, however, has not yet affected the great transportation interests to the extent it should, if, what some of the people of the country think is needed, namely, lower transportation charges, are to be obtained.

It would seem as if labor, through its great leaders, ought to recognize the fact that this deflation process is going on, admit that it must come, and allow a lower unit of wage in many directions, not only on the railroads, but in the mines and in the building trades, all of which would mean the employment of more men, and a lower unit price on many articles that are used by all, and thus tend to reduce the cost of living and help to break the present endless chain of expense.

Mr. Julius Kruttschnitt, in his interesting and readable article in the *Atlantic Monthly* for January, 1922, makes the following statement about the direct labor costs to the railroads, as the result of the Adamson Law, other Federal and State Laws of a restrictive character, the war, and the practices developed during Federal control and action by the Labor Board:

"The labor costs of Class I carriers were 113 per cent. higher in 1920 than in 1917, preceding Federal control; and if the increased wage-scale had been in effect during twelve, instead of only eight, months of 1920, the increase would have been about 125 per cent. The Government during its control allowed gross revenues to increase less than 54 per cent. Labor costs have risen since the Government took charge of them in 1916, under the Adamson law, from $1 468 576 000 to $3 698 216 000, the total amount paid to labor during 1920 being very nearly sixty times the $61 928 626 of net income yielded by the operation of the railroads.

"The history of the direct labor increase is interesting and important.

"The labor bill of Class I carriers in 1916, before the Adamson law took effect, stood at	$1 468 576 394
In 1917, when the Adamson law was in effect, the labor bill was	1 739 482 142
An increase over 1916 of	$270 905 748
This was increased by the Railroad Administration in 1918 to	2 613 813 351
Or an increase over 1917 of	874 331 209
This was further increased by the Railroad Administration in 1919 to	2 843 128 432
Or an increase over 1918 of	229 315 081
This was further increased by the Railroad Labor Board in 1920 to	3 698 216 351

or $10 132 000 for every day of the year.

"The increase in labor alone, from 1916 to 1920, was $2 230 000 000—nearly equal to $2 357 000 000, the total operating expenses of all Class I roads in 1916, which include, not only cost of labor of every description, but cost of materials, fuel, depreciation, loss and damage to freight, injuries to persons, insurance, and the rest.

"After the return of the railroads to their owners, they were made to perform the greatest transportation task in their history. They moved more freight and passengers, loaded their cars more heavily, and moved larger train-loads. That it cost too much to do this was due, as shown, almost entirely to causes beyond the railroad managers' control."

The Railroads as Buyers of Materials.

A reasonable policy of labor deflation would be extremely helpful, because the wage bill of the railroads is so large a part of their total expenses and they are such heavy buyers of materials, the cost of which is made up so largely of labor. When they are on the up-grade the railroads are very large buyers—perhaps the largest buyers—of many articles, which means employment to men and a greater demand for food and other articles.

Rates.

The country pays a big bill—through rates—for the transportation service furnished by the railroads, but the country is a big country, and the amount of transportation furnished is very large. The production of it is extremely costly, and, to-day, there is no adequate return to the plant that furnishes the service.

The returns, after expenses and taxes for 1921 (partly estimated) have been paid, will not exceed $616 000 000, not quite enough to pay the fixed charges of about $640 000 000, including the interest on bonds so widely distributed among individuals and held by insurance companies, savings banks, and charitable institutions; thus leaving nothing for improvements or the stockholder. This might be all right if the roads had been allowed in the past, as other industry has been, to earn liberally in other years.

This meager result was obtained only by the cutting of maintenance and repair work to the lowest limit consistent with safety. It has been estimated that in 1921 more than $400 000 000 of maintenance and repair work was postponed, and sooner or later, this work must be done.

It should be remembered that for many years prior to the war the general level of rates was not sufficiently high to protect this National industry of transportation, and there was a danger, to agriculture and to all classes of industry, of the supply of transportation not being adequate for the needs of the country. Therefore, to cure that economic difficulty, an effort was made through the Transportation Act and through the rates permitted by the Commission under that Act.

These rates are higher than they were before the war, but they were then far too low for safety, and we are comparing to-day with an indefensible basis, if the country is to continue private operation and ownership of railroads, subject to public regulation.

Critics of the general level of rates should remember and consider how out of balance rates were before the war and that, to-day, although some may be

too high, the general level of rates approved by the Interstate Commerce Commission in 1920, with numerous adjustments made since, is not too high, considering what the railroads have to pay for wages, fuel, and supplies generally; and it should be remembered that the increase in the United States, because of changed conditions, has not been nearly as great as the increase in transportation charges in many other countries which have suffered from the same world-wide conditions because of the increase in wages and the price for fuel and materials used by their respective transportation systems.

Rates, in Earlier Years, Too Low.

The railroads of this country have always believed in making as low rates as they possibly could, and it has been thought by some that they went too far at times. In fact, the Transportation Act recognized that danger by giving the Commission power to name the minimum as well as the maximum rate. The railroads want as low rates as they can afford, because of the great distances and because they want the widest distribution and the greatest exchange of all kinds of commodities.

The owners and managers, however, of these great railroads are trustees, holding these properties for service to the public, as well as to earn a return, and, in making their rates and in presenting facts to the public about their business, about the charges they make for service, they must realize that they have a paramount duty in maintaining a safe and adequate transportation machine, and in managing it honestly, efficiently, and economically.

To permit wastage through inadequate rates means a deterioration of the properties within their charge, which will tend to prevent their serving the public adequately; and to permit such wastage is not honest, efficient, and economical, any more than it is to permit wastage in labor, if they can control it, or in the use of material, or in any other form of management.

Many Other Factors to Consider Besides Rates.

Rates, of course, have a bearing on the development and success of agriculture and industry; but they are not the only important elements in the problem, that must be considered before improved business conditions obtain.

For example, to-day, the labor cost of building a house is far more important than the rate on the material itself, and the labor cost is a much greater deterrent to solving the important housing problem of the country than the railroad rate. This labor cost goes back into the lumber, the steel, the iron, the brick, the cement, into the railroad rate, and, it is evident, in the wages received by the men actually engaged in placing the material, after it has been put on the ground, in the form of a house.

It is very important, not only for the railroads, but for the public, to be just and without prejudice, and to realize that there are a great many factors besides rates which are affecting business to-day.

A sweeping reduction in all rates would not, in the speaker's judgment, at this time increase business, for many other things must be settled before we obtain what all desire, that is, a complete revival of industry in this country.

The speaker refers to such matters as the various foreign questions which seem to be in a fair way of adjustment by the Disarmament Conference now going on in Washington; the tariff question, which Congress now has in hand, and which is most difficult; the tax question, which has been partly settled and which is even more difficult than this railroad rate question, and the general financial condition of the world.

The Transportation Act.

In regard to the Transportation Act, which, to-day, is the guide for the railroads, the regulatory bodies, and the public: The country debated the general subject for a long time, Congress did the same and finally passed the bill. It has been the law only about twenty months. During some of those months, business has been depressed and disturbed, and it can truthfully be said that the Act has not had a fair trial. Only a little more than a year ago, the cry of the country was not about rates, but about the inability of the railroads to handle all business promptly. That condition is likely to exist again when business resumes, if proper steps are not taken.

The country, in that Act, declared for a National railroad policy, and the supreme power of the nation, through the Commerce Commission and the Labor Board, over questions of dispute as to rates and regulations thereof and wages and working conditions, respectively; also for a policy of self-support for the railroads out of the rates charged for transportation furnished to the public. The public, after this long debate, turned away from the doctrine of supporting their transportation system through taxation, and also turned away from Government ownership. It will be most unfortunate for the country to turn back to Government operation or ownership, because of the present difficult conditions from which it will emerge in due time.

Economies in Transportation.

Improvements in transportation practice have been continuous for a long term of years, and the total accomplished is likely to be lost sight of. Not so many years ago, all the land transportation in the country was furnished by packing on the backs of men or animals; to-day, there are being handled with the aid of less than 2 000 000 men, more than 400 000 000 000 ton-miles of freight each year. The physical effort to do this represents, under the old methods, the labor of about 1 250 000 000 men, and the cost to the public has decreased from $3 to about 1¼ cents per ton per mile, based on 1921 returns.

Of course, it would be impossible to apply this amount of man power, but the comparison is given to show how the efficiency of the railroads has released untold man power for the great development of the country in many other directions. It may be argued that highway transportation would have developed even more than it has if the railroads had not been here and the country, therefore, served by highways and waterways. Without the railroads—the primary form of transportation in the country—the motor vehicle, the gasoline to propel it, and the hard surfaced roads never could have been developed except to a limited extent.

Every progressive railroad manager knows that some further economies are possible, but they depend largely on two factors that cannot be made effective at once: First, the spending of money for capital account in the creation of better facilities; and, second, the actual price paid to the individual workman and the development in him of a spirit that it is his duty, as an American citizen, to do all he can to bring down the cost of transportation, because of the help such reduction will be in working out the soundest possible general economic scheme for the whole country. This same idea ought to be applied to those who work in mines, factories, and forests, because fuel and material prices affect all and very largely depend on the efficiency of the individual man and the wage paid.

The engineer is peculiarly in a position with his trained and accurate mind to help in determining the wisest form of improvements in transportation facilities and practices to be made (if and when money can be obtained) for increasing economies of operation. Among economies that are not completely developed are:

1.—Further decrease in the physical resistance to be overcome so as to lessen the tractive power necessary to haul a ton of freight.

2.—Improved location and design of terminals both for handling carloads and merchandise; improved water and fuel stations.

3.—Great economies in the production and use of power from steam and electricity, whether obtained from fuel or water power.

4.—Improved design of locomotives and cars so as to have the maximum of capacity and strength with a minimum of dead weight.

5.—A better supply of well-designed repair plants equipped with high-powered and rapid-working tools in all shops and roundhouses, where mechanical work is performed.

6.—Improved methods of receiving, storing, and distributing the great quantities of materials and supplies that are used each day by the railroads.

7.—The elimination of waste which is prevalent in all walks of American life.

The Future.

It is not beyond belief that within fifty years there will be 250 000 000 people in the United States. They can be well cared for if every one will co-operate and work. Vital to their well-being, however, will be an adequate transportation machine. To-day, the country has one made up of the railroads, seaways, waterways, highways, and motor transport, representing great values, possibly $60 000 000 000, or next to agriculture as an element of National wealth. Of this the present railroad system, on any fair basis of allowance for good will, strategic position, experienced organization, and all the elements that enter into values of other classes of property, is probably worth $25 000 000 000. When there are 250 000 000 people, a ton-mileage of even 3 000 per annum instead of the present 4 000, to give them as good a living as is being furnished to-day, will mean the movement of 750 000 000 000 ton-miles per year plus the added passenger travel—double that now provided.

Thus, the present great transportation machine must be enormously added to, possibly doubled, not in mileage, but in capacity and co-ordinated with other forms of transportation. Great sums of new capital must be obtained, probably more than $25 000 000 000, and this can only be obtained if there

is safety for the principal and a fair annual return. The engineer is particularly interested in having this work go on, because of the important part he will play in it, as well as in the development of economies in the existing system.

The country and the world are somewhat in the "dumps", but times will change and conditions will be better. The speaker believes that the United States is on the threshold of the most glorious period in its history, and that Americans can take a place in the history of nations never before achieved if they will only think right, work hard, and use carefully their great powers and resources; and the transportation machine should at all times be kept adequate to the growing needs of the country.

The Engineer and Social Progress.

The railroad system of the country has been and is a great engine for advancing civilization. The engineer has played a most important part in creating and operating this engine. With the great development in the United States, however, and the crowding of people into cities, have come perplexing social problems which must be attacked and solved if the country is to achieve its highest destiny. Some of these are:

(*a*).—*Better Use and Conservation of Natural Forces and Resources.*—Nature has been generous to the United States and the people have not been obliged to save in the past as much as they must in the future. The engineer, by perfecting the processes for developing and conserving resources can help to bring about better living conditions and promote National health and National safety. Think of the possible development in the next fifty years along the lines of fuel conservation, use of cheaper forms of coal for power, water-power development, control of the flood waters in valleys and control of water in the mountains for irrigation. The better use of natural forces and the elimination of waste in use of natural resources are most important.

(*b*).—*Decentralization of Population.*—In 1880, 14 358 167 people lived in cities and towns and 35 797 616 in the country. In 1920, this had changed to 54 304 603 for cities and towns and 51 406 017 in the country.

Cheaper fuels and wider distribution of power will permit a wider use of mechanical devices on the farm, in the small home, and in the small factory, and by increasing comfort and convenience in the country, check the drift to the city.

(*c*).—*Better Rewards for the Farmer.*—The cost of living can be reduced if there is a National policy leading to the better use of resources, and more people willing to produce food.

Agricultural and farm life however, must offer attractions and rewards to the young people equal to what they think can be obtained in the cities.

(*d*).—*The Relation of Labor and Capital.*—The distribution of the annual increment of wealth in the country very properly is a subject that engages the attention of every one. Each one naturally desires to obtain all he can consistent with regard to others. Out of this natural effort great organizations of labor and of capital have developed. Such organizations are all right

if wisely and honestly directed. Labor unions are all right when they are so conducted that waste is eliminated and they are an efficient and economical instrument of society as a whole. When they cease to be that, their usefulness is gone and society will get rid of them. There is a place in this country for wisely directed labor unions, but no place for labor tyranny.

Society some time ago discarded the club, the sword, and the pistol as weapons for the settlement of personal disputes. Society is getting ready to discard the strike as a weapon for settling industrial disputes, because it is inhuman and uneconomical, the sooner the better for the good of all.

The engineer is of great importance because of his technical knowledge and trained mind. He is of almost greater importance, however, as a citizen, because he has been trained to be accurate in thought, his calculations must check out, or he fails. He can be of great value in working out some of these social problems, and he can and should counteract the loose thinking and talking that is more or less prevalent, resulting in the advocacy in legislative halls, on the stump, and in parlors, of foolish doctrines that never have worked and never will.

The majority of people in the United States, as individuals, are sensible, hard-working, and home-loving; but, collectively, they are sometimes led astray through lack of accurate information and clear thinking. The World War developed a spirit of extravagance and unrest, and there is a noisy minority doing a great deal of talking and advocating what, for want of better names, are known as Radicalism, Socialism, Bolshevism, and the use of remedies that may do more harm than good. The engineer, as a citizen, can use his trained mind to help prevent the theorists and adventurers from leading the country astray so that we may jump out of the "frying-pan" of admittedly difficult conditions into the "fire" of much worse ones.

The engineer, accustomed to basing conclusions on accurate facts, can help create a public opinion: That an adequate transportation machine is a necessity; that it cannot be had without paying for it; that the present railroad system was developed by giving the initiative of the American man some chance to work and to obtain rewards; and that better results can be obtained in the future if that initiative is allowed once more to be used without all the hampering and restrictive laws of Nation and States that have been put on the statute books in the last twenty-five years.

Railroads are common carriers of people and property; they are not common carriers of all the economic troubles of the country. These cannot be cured by reducing rates, by ruining the railroads, and perhaps forcing Government ownership to which this country is opposed. Give brains, courage, and management a chance once more. Declare a ten-year holiday in the ceaseless investigation of the transportation question, and let the undivided attention and energy of owners, managers, and employees be devoted to maintaining, operating, and perfecting this engine of civilization—the wonderful railroad system of the United States.

The Society, and its members all over the United States, are a powerful influence for wise and economical work along technical lines. They are, and can be, a powerful influence in moulding public opinion along sane lines,

so that the National problems will be settled in the interest of all the people; but all hands must work. There is an old hymn of three stanzas, one of which reads:

> "We are not here to play, to dream, to drift;
> We have hard work to do, and loads to lift;
> Shun not the struggle—face it, 'tis God's gift."

This is good doctrine for all of us in these days when the world is trying to adjust itself.

RAILROADS AND THEIR EMPLOYEES

By W. N. Doak,* Esq.

Some of the world's greatest men have been engineers and engineers have blazed the way for civilization and progress through the different stages of the world's development. The achievements and progress of mankind are so interwoven with the work of civil engineers that it may properly be said they have been the arbiters between nations and subdivisions thereof.

The subject assigned the speaker could be used for an indefinite discussion, but he will advance only a few observations on the subject of the relations between the railroads and their transportation employees. These conclusions are the result of more than 20 years' observation and several years' practical experience, most of which time the speaker has had the pleasure of personal contact with both railway managements and railway operatives. What is said will be devoid of any tinge of partisanship and will be a statement of a personal conviction.

The relation between employer and employee engaged in the transportation industry should be the most cordial, because in reality they are both employees of this great institution engaged in a public service. Both should be treated fairly by the public, and impartiality should guide in the consideration of all questions affecting either.

Disputes between railway managements and the transportation employees are largely unnecessary and almost wholly preventable through a closer relation and a more friendly feeling, combined with the exercise of calm judgment and the use of common-sense principles. The greatest menace to industrial peace is the lack of proper understanding between employer and employee, which, in many instances, is the result of thoughtlessness and carelessness and aggravated by undue outside interference and improper design.

Differences often spring from the poisoned well of ill-advised propaganda, which is either devoid of all truth or is inspired by the greater menace, half-truths. Half-truths are far worse than whole falsehoods. The speaker is convinced, therefore, that what is needed above everything is the exact truth in all instances. Truth accurately arrived at by and through the process of calm, unbiased investigation by practical, experienced investigators, and the facts thus obtained applied in the most practical manner.

Neither unscientific conclusions nor half-hearted investigations by impractical unreliable investigators can result in other than damage and harm. Harm to the one must eventually result in harm to both management and men and in the end be dangerous to the industry. Temporary advantages to either will ultimately result in disadvantages to all parties at interest. Both employer and employee, and, in fact, the industry itself, have been the victims of unjustifiable assault in many instances by the public through the lack of proper understanding which, in turn, was the result of partisanship and improper publicity. The money spent in publicity and the energy expended to gain a temporary advantage should have been used to arrive at truths and in the

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dissemination of facts to the public instead of the ill-advised course pursued in so many instances. An unbiased judgment compels the speaker to state that his observation is that the industry is all right, the management is all right, and the employees are all right, if permitted to follow a normal and proper course, and by the united efforts of all the greatest protection is guaranteed to the transportation industry.

Probably one of the pastimes most largely indulged in by the average citizen is the discussion of railroad problems. Bitter partisanships have been made, and, in most instances these partisans cannot give any logical reason for being aligned with either the railroads, the managements or the men. The reason for this is largely due to ill-advised publicity in the form of paid advertisements, editorial columns, or utterances from the public platform by intense partisans. In most instances, those engaged in the dissemination of this propaganda are wholly uninformed as to the exact facts, or deliberately refuse or neglect to state all the facts. Suppose, for the sake of comparison, a dispute should arise as to the boundary between two States, which resulted in an intense partisanship, and all kinds of propaganda was used by the parties at interest. No attention whatsoever would be paid to any such propaganda unless and until experienced engineers had run the line and passed judgment on this question, thereby arriving at the facts. This has not been the manner in which railroad questions have been judged, nor has it been proposed that they be dealt with in any correct manner. The point is that any other dispute besides a railroad labor dispute and certain other railroad questions, is always settled by experienced and practical men, whereas it is proposed for the public to settle these disputes with impractical and inexperienced men.

After a half century of agitation, experiment, and countless discussion, railroad men find themselves drifting in a more disturbed and uncharted course than at any time in twenty years, when it comes to the adjustment of railroad labor disputes. Strikes and lock-outs, mediation, conciliation, arbitration, Courts, boards, and other plans, have been tried, but the present time marks a very unsettled condition.

Railroad men have the experience of the United States and also the benefit of the experience of almost all civilized countries. This affords an opportunity for comparison and after so doing, voluntary methods have been found to be the most effective and far outweigh those of other countries. The most effective remedy has been voluntary mediation, conciliation, and arbitration. The Erdman Act and its amended Act, known as the Newlands Law, proved by far the greatest means of accommodation of any other plan tried in the United States or any other country. This Act was suspended temporarily during the period of Federal control, and all questions were settled by boards of wages and boards for the adjustment of other disputes, bi-partisan in character, with the Director General of Railroads as the referee in case of deadlock. With the termination of Federal control and the enactment of the Transportation Act of 1920, the United States Railroad Labor Board was created, and provisions were made for voluntary bi-partisan adjustment boards, the Labor Board to have jurisdiction over all disputes that were not adjusted by other means and to act as referee in case of deadlock by adjustment boards. This method is still in

existence and the speaker does not believe it has been sufficiently tried out to form a correct conclusion as to its effectiveness. He has believed, however, that no tri-partate board would ultimately be successful because of the inexperience and lack of knowledge on the part of one-third of the membership. Furthermore, the element of partisanship is not eliminated when there is any possibility of having a third party to whom the responsibility may be passed.

Some countries have tried Industrial Courts, in fact, one of the States is now trying out this plan. These did not work satisfactorily in any country where they were tried, and they have not proved adequate or desirable as a method of accommodation for disputes involving interstate commerce employees in the United States. The Kansas Industrial Court did not prevent the outlaw strike of railroad employees in 1920, nor did it prevent the recent strike of miners in that State. Of course, a few men were sent to jail, but this did not keep the miners on the job, nor can any Act be passed in this country, where free labor is guaranteed by the Constitution, that will keep individuals on the job. The Industrial Courts of Australia and the Australasian countries eventually proved a failure.

The Industrial Disputes Acts of Great Britain and of Canada have not proved as effective in the adjustment of disputes as the laws in the United States. As a matter of fact, in the same dispute involving men on both the American and Canadian sides, an accommodation was had under the Newlands Act in the United States and a failure under the Canadian Industrial Disputes Act. In fact, peace was secured under the American laws and the Canadians had a strike and industrial war.

Compulsory arbitration laws have been enacted in a few countries and they have failed for the reason that individual freedom prevents men from being compelled to work against their will. No such law could be effectively enforced in the United States, because the greatest freedom is accorded the individual working man in ceasing his employment when he pleases.

Another experience in this country in the adjustment of disputes between the railroads and their employees that has proved to a degree very satisfactory is through the agency of voluntary bi-partisan boards of adjustment, on which employer and employee were equally represented. Also, a plan of this kind was tried for the adjustment of disputes between the anthracite coal operators and the miners, following the anthracite strike during the Roosevelt Administration, and this plan has been in effect since that time preserving industrial peace in this industry. The speaker believes the printers and their employers adopted a somewhat similar plan which has been in effect for a number of years, but in each instance, of course, a referee was selected in event of failure of agreement or in case of deadlock.

This brings up a discussion of the merits of various plans and to conclusions as to how disputes should be settled between the railroads and transportation employees.

Conciliation.—Conciliation has been valuable in getting the parties to meet and settle their differences in conference after one or both had refused conference or declined to proceed further with negotiations. This has been very helpful and has paved the way for many settlements, either by direct

negotiations, through mediation or arbitration. It should be encouraged and stimulated, if for no other reason than that it results in direct conferences between the parties and acts as a stimulant to the principle of settling differences around the conference table at home.

Mediation.—Mediation has been the most potent factor of the many principles applied to the railroad industry. In many instances after conciliation had failed, mediation was successful in bringing about an adjustment of the dispute by the mediators meeting the parties separately or collectively and aiding them in composing their differences. In other instances, arbitration has resulted from the efforts of mediation and proved to be successful. High-class mediators should be provided by law or by voluntary arrangement, preferably by law.

Arbitration.—Voluntary arbitration has been of mutual benefit in the adjustment of controversies on the transportation line. However, in each instance, these have been voluntary and they should be so continued and only resorted to after every attempt at conciliation and mediation has failed. Both railway managements and employees are committed to the principles of arbitration. In the speaker's opinion, it should be the least resorted to of any other plan, and when taken advantage of, the rarest care should be exercised in the selection of the boards, especially in the selection of neutral members of such boards. Arbitration has largely failed or fallen into bad repute because of unwise selection of neutrals and in the administration of arbitration laws rather than to any lack of merit in the principle. Some method for the creation of voluntary arbitration boards, to be used when desired, should be provided.

Bi-partisan Boards of Adjustment.—Bi-partisan boards of adjustment for transportation employees originated after the passage of the Adamson Eight-Hour Law. It was necessary for some one to apply the principle of the 8-hour day to the several hundred wage agreements between the railroads and the four transportation organizations, and as a result a committee of eight was agreed on, consisting of a railway representative from each of the different territories and a representative from each of the four transportation organizations. This Commission handled approximately 30 000 cases during the year it was in existence, and, fortunately, agreed on each case. With the commencement of Federal control, the question arose as to the handling of not only 8-hour questions, but all other disputes, including wages, discipline, etc. It was then arranged to appoint a board of eight members to handle all grievance matters other than wage disputes for the transportation men, the Director General of Railroads to be the referee in case of deadlock. Afterward, similar boards were created to handle such matters for other classes of employees. After the Lane Commission handed down its wage award, it was agreed to appoint a committee to handle wage questions, with the right to recommend changes in wage rates to the Director General of Railroads.

The adjustment board for the transportation employees handled more than 3 000 disputes without a deadlock. The other adjustment boards likewise did good work. This experience brought the industry up to the close of Federal control in good shape, and with the benefit of a most valuable experience.

The Transportation Act of 1920 then provided for voluntary adjustment boards for the adjustment of disputes other than wage questions and a labor board for the adjustment of wage disputes and to act as referee in cases of deadlock by adjustment boards. Boards have been recently created for some of the railroads and the transportation employees and are now functioning. These should be continued and encouraged.

Conclusions.—What is desired above everything is industrial peace coupled with fairness and proper treatment alike to the railroads, the management, and the employees. The speaker, therefore, would recommend the following:

1.—Every effort should be exerted through direct conference and meetings of the employees with their employers in an effort to adjust any controversy between the two.

2.—Agencies to provide mediation and conciliation with the right to propose voluntary arbitration should be re-established at the earliest possible time, and rare judgment should be exercised in the selection of high-class men for such positions.

3.—Regional adjustment boards, bi-partisan in character, should be established and all railroads and their transportation employees represented thereon, to which would be submitted all disputes that could not be adjusted otherwise.

4.—The United States Railroad Labor Board should be continued until a fair trial has been accorded it and an accurate estimate made as to its value, this Board to adjust such wage disputes as are not adjusted otherwise and to act as a referee in case of deadlock by adjustment boards.

5.—The practice of agitating, either through the public press or otherwise, questions that are likely to disturb the public mind and cause alarm among the people regarding railroad questions and railroad labor matters should be discouraged and if possible entirely eliminated, and in lieu thereof agencies established for a fair impartial investigation of all such questions by which to arrive at accurate facts.

6.—The public, the railroads, the management, and the employees should unite in a campaign of education that would restore confidence in the industry, through the dissemination of nothing but facts in dealing with questions affecting the railroads.

With these few suggestions, the speaker hopes the future holds in store an unbroken era of industrial peace and likewise a revival of confidence and prosperity in the railroad industry. With this important industry prosperous, all interests must prosper and the railroads are usually one of the most accurate business barometers. He hopes, therefore, that the Society will join with those in the railroad world in an endeavor to restore not only prosperity but a public confidence in this great American institution and that these problems will be judged from a practical, business standpoint and all the theories, speculations, and cries of the so-called reformers disregarded.

RAILROAD TRANSPORTATION AND OWNERS OF RAILROAD SECURITIES

By F. A. Molitor,* M. Am. Soc. C. E.

Of recent years a new element has entered the railroad problem: the security owners. The narrowing margin in the net operating income of the railroads, from which interest on bonds, dividends on stock, and improvements to property must come, occasioned such misgivings that the National Association of Owners of Railroad Securities was formed for the purpose of protecting their interests.

The date, September 6th, 1916, when the Adamson Act was unfortunately passed to avert a strike threatened by a strong combination of railroad unions, was an important milestone in the history of American railroads. It marked the beginning of the decline of the credit of the railroads of this country and evidenced the great political strength of the railroad unions, working for the first time in a strong combination.

From that date, the investing public ceased their former interest in, and purchase of, railroad securities. This withdrawal of interest and support on the part of the public from the purchase of railroad securities, is evidenced by comparison of sales before and after 1916. From 1910 to 1915 the percentage of sales of railroad bonds to the total sale of all bonds on the New York Stock Exchange averaged 93 per cent. In 1916 the sales of railroad bonds declined to 73%, and, in 1917, to 44½ per cent. During 1918 and 1919, the sales declined to 11% and 12%, respectively, which low percentage, however, was caused by the large volume of Liberty Bonds sold during these years. In 1920, the percentage of sale of railroad bonds to all bonds was 20½, and, in 1921, it was 31.

Some well-informed investors commenced even in 1916 to dispose of railroad securities, but institutions such as savings banks, insurance companies, etc., that held large amounts of railroad bonds were not able to dispose of their large holdings without a further and more serious disturbance of values, so that to-day it is probable that the railroad bonds are largely held by these institutions and trust estates, and, relatively, a few individual investors.

The very direct interest in these bonds by saving bank depositors and insurance policy holders is manifest. The savings banks and other banks of the United States hold about $1 700 000 000 par value of railroad bonds and there are 10 000 000 depositors in these banks. The insurance companies hold about an equal number of railroad bonds ($1 520 000 000). The policy holders number 34 000 000. In all, this represents about 32% of the total railroad bonds outstanding. These 44 000 000 people can wield a great political power and, in the last analysis, control the political situation in the railroad problem, if they can be aroused to act together through their organization.

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The withdrawal of the support of the investing public from the railroad security investing field between 1916 and the entry of the United States into the World War would have produced an immediate financial crisis, were it not for the enormous business that came to the railroads by reason of the purchase in this country of munitions of war by the Allies. Indeed the years 1915, 1916, and 1917, commonly called the "test period", were years of considerable prosperity to the railroads, due principally to stimulation of business caused by war demands. During these three years, the average net return on the investment account of Class I railroads was 4.52%, while the net return for the fiscal year 1921, with December estimated, was only 3.28 per cent.

The taking over of the railroads by the Government, as a war measure, on December 31st, 1917, the speaker has always personally felt was quite unnecessary. They could have functioned as well under some temporary unified control which readily could have been accomplished through the aid of the Government. This would have avoided that Government operation which has done so much to destroy operating efficiency and the consequent credit of the railroads.

Railroad labor, by reason of its efficient organization, had placed on the statute books, beside the Adamson Law, the Full-Crew Laws in various States and other unnecessary legislation which increased operating expenses without any compensating advantages to the railroads or to the public. The railway executives then (in 1917) formed an organization in order to present to the public and to Congress the point of view of the management and stockholders, as well as to handle negotiations with their labor on a common basis, made necessary by the common organization of railroad labor. In September, 1917, it became necessary for the security owners, largely represented in bond holdings, to form an organization so that their own voice and viewpoint might be heard, and their particular interests as owners of the primary securities presented to Congress and the public. Their Association was formed through the personal energies of Mr. S. Davies Warfield, who has been its President to this day. This organization is in effect a bondholders' protective committee for all the railroad bondholders, acting for all securities, and not on behalf of any group or single system. The necessity of their action is due to the decreasing margin applicable to fixed charges and dividends of all the carriers.

The interests of the Security Owners acting for the bondholders, the railroad executives who operate the properties and represent the stockholders, and the general public, are necessarily one.

The Security Owners Association was mainly, if not wholly, responsible for the inclusion in the Transportation Act of 1920 of that provision for a measure of rate-making, which, unfortunately, has been called the "guaranty" provision. It is no guaranty at all. Otherwise, the existing deficit below the 6% return would have to be made up from taxation. It provides that the measure of rate-making shall be such as in the aggregate by groups will yield a 5½ to 6% return on the valuation of the railroads. This provision

expires on March 1st, 1922, and many efforts have been made to remove it from the Act. These untimely efforts have occasioned much concern to the investors, because the provision is a guide or "yardstick" for the making of compensatory rates, heretofore defined under the anomalous words "fair return". These efforts of the agricultural and other interests to obtain the removal of this provision is increasing the alarm of the investor concerning railroad securities. The apparent policy of the Interstate Commerce Commission and some of the railroad managers to yield to this pressure and to decrease rates in the face of the existing low net return adds to this alarm.

After the passage of the Transportation Act many influential public interests of the country, and many of the railroad managers were hopeful, if not enthusiastic, that the Transportation Act would stabilize the policy of regulation so as to enable the railroads to rehabilitate their properties and restore the operating efficiency lost during Federal control. The business depression which hit the railroads during 1920 and 1921 was, of course, unavoidable. It came from world-wide economic causes and to-day much liquidation, has taken place. The railroads have had their full share of this liquidation, as have the large industries, but, unfortunately, while liquidation in wages in the broad industrial field has taken place, it has not, except to a very small extent, occurred in the ranks of railroad labor. They are still receiving within 10% of their peak wages. The lack of liquidation in the ranks of railroad labor is shown by Tables 6, 7, and 8. From Tables 6 and 7 a comparison of indices of average compensation of railroad employees with cost of living may be made. Table 8 gives a comparison of railway wages with some other wages.

TABLE 6.—Average Annual Compensation per Employee in Percentage on Basis of Fiscal Year 1913: Class I Railroads.*

Month.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
January	....	....	...	....	....	....	....	209	235
February	....	. ..	....	....	....	....	....	209	235
March	....	....	....	....	....	....	....	209	235
April	....	....	....	....	....	....	....	210	234
May	....	....	....	....	....	....	....	250	234
June	100	107	108	112	....	....	....	249	234
July	....	....	....	....	....	....	....	256	207
August	....	....	....	....	....	....	....	256	214
September	....	....	....	....	....	....	....	256	205
October	....	....	....	....	....	....	....	250	....
November	....	....	....	....	....	....	....	250	....
December	....	....	....	116	132	186	195	250	....

* Compiled from Statistics of Interstate Commerce Commission.

The railroad security owners have also taken more than their full share of this liquidation, as evidenced by the comparison of net return of the past 12 months with the return during the "test period". The Federal Government and the various political sub-divisions have not assumed their share of the liquidation, in that there is no reduction in the taxation of the railroads. Indeed, this item has been increased alarmingly. In 1912, the total taxes

derived from railroad property by various governmental agencies, that is, Federal, State, and municipal, was $109 500 000. In 1921, this has increased to $490 000 000 or 348 per cent. This, however, includes the Federal tax on transportation amounting to about $200 000 000. The abolition of the Federal tax on transportation in 1922 will reduce the amount of taxation by $200 000 000 to $300 000 000 annually, dependent on the volume of business. This item, however, represents the amount paid by the public to the railroads, which is passed on as a payment to the Federal Government. An interesting comparison in this connection is that Class I railroads paid (in addition to the transportation tax) in 1921 to the Federal, State, and other governments about $290 000 000, while the amount they paid in dividends during 1920 to stockholders was $271 000 000, so that the owners of the railroad properties received less than the Government.

TABLE 7.—Cost of Living, in Percentage, on Basis of July, 1914.*

Month.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
January	....	....	....	....	....	....	....	190	181
February	....	....	....	....	....	....	....	194	176
March	....	....	....	....	....	....	161	195	169
April	....	....	....	....	....	....	....	197	168
May	....	....	....	....	....	....	....	202	166
June	....	....	....	....	....	152	....	203	162
July	100	100	101	109	131	....	172	205	163
August	....	....	....	....	....	....	....	203	162
September	....	....	....	....	....	....	....	199	165
October	....	....	....	....	....	....	....	197	164
November	....	....	....	....	....	165	182	193	....
December	....	....	....	....	....	....	....	190	....

* Compiled from Statistics of National Industrial Conference Board.

TABLE 8.—The Relation of Railroad Wages to Some Other Wages.*

Year.	Railroad union wages.	Seventy-two other union wages.	Farm wages.	Combined crop and livestock prices.
1913	100	100	100	100
1914	105	102	99	103
1915	109	103	100	98
1916	113	107	109	119
1917	129	114	137	185
1918	189	133	171	207
1919	227	155	202	213
1920	272	199	235	185
1921	288	....	192	122

* *Industrial News Survey*, January 7th, 1922, p. 6.

The result of all these happenings contained in this true but pessimistic picture, is that the credit of the railroads is to-day at the lowest ebb. Unless the railroad problem is removed from politics, and an economic and liberal policy is pursued in regard to the railroads, the result can only be financial disaster or early Government ownership.

In regard to Government ownership, the campaign made in its favor by the railroad unions in support of the so-called Plumb Plan, may be re-

called. This did not receive public support. However, since the passage of the Transportation Act in 1920, the general public has been lulled into security and peace in respect to Government ownership. The undercurrent of political affairs is such that many believe public ownership of railroads is closer to-day than it was three years ago. The effective force that worked in its behalf then, is working as effectively now, and the meager return to the carriers, since the passage of the Transportation Act, is helping the movement along.

The happenings which the speaker has briefly reviewed and which have made for the impairment of railroad credit, may be summarized as follows:

1.—The passage of the Full Crew and other unnecessary laws by several States.

2.—The refusal of the Interstate Commerce Commission to increase rates in 1915.

3.—The passage of the Adamson Law.

4.—The inability of the railroads since 1916 to finance needed improvements, especially terminals.

5.—Government operation during the war.

6.—Increase of wages granted by the Railroad Labor Board in July, 1920, retroactive to May, 1920.

7.—The agitation to abolish the provision of the 6% return of the Transportation Act of 1920.

8.—The decrease in many freight rates below those established by the Interstate Commerce Commission in August, 1920, in accordance with the Transportation Act.

9.—The slowness in reducing wages, which thus far has only amounted to approximately 10 per cent.

10.—The extreme deliberation on the part of the Administration in settling the railroad claims for rentals, deferred upkeep, etc.

The failure to adjust wages to the decreased cost of labor, and to maintain the freight rates to the tariffs adopted by the Interstate Commerce Commission, in August, 1920, particularly, is shown in the operating results of the carriers for the calendar year 1921. With December estimated, the net operating income of Class I carriers was about $610 000 000, or a return of 3.28% on their tentative valuation. They failed by about $505 000 000 to earn the 6% return contemplated by the Transportation Act, under the freight tariffs made thereunder.

Furthermore, this small return was at the expense of maintenance of way and equipment, and is inflated to the extent that the railroads failed to expend a normal maintenance amount. The speaker estimates that about $400 000 000 (or 20%) more should have been spent in 1921 to have properly maintained the railroad plant. Had this been done, the return would have been 2.15% less, leaving a net return slightly over 1 per cent. Therefore, this is the figure the readers are asked to carry in their minds.

These results are no reflection on the excellent management of the individual railroads. Maintenance expenses were necessarily cut to the bone in the attempt to provide available funds to meet interest requirements. The

excellence of the management by the railroad executives of their properties is amply shown by the fact that they have thus far avoided receivership.

It would not become an engineer to paint a gloomy picture of dark clouds without the touches of a silver lining. Indeed, it is his duty to the public to suggest remedies for economic disturbances. He has been taught by contact with Nature to be constructive, not destructive. So the speaker boldly suggests these remedies for the railroad problem:

First.—

A.—Discontinue any further general reduction in freight rates.

B.—Adjust railway labor wages to conform to the cost of living.

C.—Transfer the Railroad Labor Board to the Interstate Commerce Commission.

D.—Continue the 6% return as a measure of rate-making after March 1st, 1922.

Second.—

A.—Employees of any transportation or public utility should be prohibited by statute from striking.

B.—The incorporation of all labor unions, the members of which are engaged in the transportation of any vital necessity to the public, should be insisted on and should be required to file full financial reports with the Secretary of Labor. It should be further required that all ballots be secret ballots and counted under the supervision of a representative of the Department of Labor.

Other measures are necessary to the rehabilitation of the railroads, but on account of the complications and magnitude of some of them, steps leading to their accomplishment must be taken with more deliberation than any of those just stated. Their adoption, the speaker is certain, will appeal to the professional mind, which also will recognize their economical possibilities. These economies, when proved effective, can then be passed on to the public in the shape of reduced rates, and in the speaker's judgment, until these economies are effected, the rates cannot be safely reduced with the present business, and with the present outlook for business in the immediate future.

Of these measures the speaker refers first, to the consolidation of railroads, in respect to which he has many personal doubts. However, political conditions have become such, and the public demand for consolidation is so strong, that it appears likely that the railroads of the country must be consolidated into a comparatively few systems, somewhat as suggested by the Chairman of the Senate Committee on Interstate Commerce, Senator Cummins of Iowa. If consolidations are based on a sound financial and operating structure, they will automatically cause the unification of the larger terminals.

The second measure is the terminals. The co-ordinating or unification of the larger terminals and their operation under a single management will undoubtedly reduce the capital used therein, as well as save duplication of operation. Store door collection and delivery in some cities, like New York and Chicago, will make for savings in trucking costs.

Third and last is the standardization of the freight equipment of all the railroads and a centrally controlled car-pool.

The speaker is strongly of the conviction that these three suggestions, if they can be carried out, will effect enormous savings in the general operating account, which, when passed on to the public in the shape of freight rates, will more than satisfy even the most critical shipper.

In closing, the speaker is sure that he expresses the sentiments of the President, and Board of Directors of the National Association of Owners of Railroad Securities, when he states that their endeavor is to save the credit of the railroads, to avoid Government ownership, and to assist wherever it may lie in their power, those able servants of the public, the railroad executives, and this opportunity is taken to state that it is hoped by its Committee to suggest the inclusion of the financial means of their accomplishment.

The Security Owners Association has asked Congress to incorporate the National Railway Service Corporation, which if thus chartered will be enabled, with the assistance of the large security owners of the railroads comprised in its membership, to finance the unification of terminals, the furnishing of freight equipment, and to suggest a method of car-pooling, all of which may be done without profit and with a great saving to the railroads.

DISCUSSION ON RAILROAD TRANSPORTATION

By George W. Simmons, Esq.

George W. Simmons,* Esq. (by letter).†—The transportation situation is one of the fundamental considerations of business at the present time. Although the writer is convinced that it can be technically proven that most rates to-day are not the primary cause of low prices or depressions, he is convinced, nevertheless, that there is an insistent public demand that rates shall be reduced. If this demand is not met by a reduction based on intelligent and economic lines, then there is a danger that the public will insist on a reduction anyway. No reduction should be made unless it is by reason of reduced operating costs. The railroads to-day are not economically operated, as compared with other industries. There is still extravagance and waste, largely by having several men to do the work one man could do, and by paying for work not actually performed—all the result of regulations governing working conditions inherited from the Federal Administration. The interests of the people demand that railroads be operated as nearly as possible on a business basis of efficiency and economy, and that the resulting savings be translated to the public in reduced rates.

The sentiment of the public to-day is overwhelmingly against Government ownership of railroads. The writer has recently taken a poll on this subject from about 500 salesmen, whose reports in the past on such matters have been proven practically 100% accurate. The reports show that the only sentiment favoring Government ownership is among railroad employees and organized labor, and among those who believe in Socialism. A few scattering reports indicate that some farmers are almost willing to try Government ownership as a means of lowering rates on farm products. In almost all sections, however, there remains a recollection of Government operation and almost universally the sentiment is "never again!"

Farmers generally are getting so much less for their products than what they are entitled to, in proportion to what they have to pay for other things, that they are inclined to listen to the demagogue who tries to fasten the blame on high freight rates. Farmers generally recognize, however, the necessity for the Federal regulation of car supply and adequate service to carry their products to market, when there is a market. Many of them, however, do not recognize that the chief trouble with the price of American farm products lies in Europe and other foreign countries, and that the freight rate has little if any influence on the quantity of cotton, wheat, and hogs that are exported. The lack of market rather than the transportation charge is the fundamental reason for the low price of farm products.

If railroad rates can be reduced soon, with a corresponding reduction in operating costs, it will do more to start the wheel of prosperity throughout the country than any other one thing. The repeal of the Adamson Law and the readjustment of railroad labor costs, together with "a fair day's work for

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a fair day's pay", if coupled with a definite policy of refunding the international loans, will start things going briskly.

Whether it is realized or not, the people are drifting rapidly toward Government ownership, and although the Nation plainly rejected the Plumb Plan and the vast majority of the people are against it, it may be adopted, unless the credit of the railroads is protected and any shortsighted action prevented which would in effect produce Government ownership and operation of the railroads.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

HIGHWAY TRANSPORTATION*

A SYMPOSIUM

By Messrs. Thomas H. MacDonald, William G. B. Thompson, John N. Cole, E. A. St. John, Edward C. Lunt, Harry Meixell, R. S. Parsons, and G. Wythe Munford.

With Discussion by W. K. Hatt, M. Am. Soc. C. E.

* Presented at the meetings of January 20th, 1922.

HIGHWAY TRANSPORTATION

By Thomas H. MacDonald,* Esq.

A recent study on the State highways of California made by the United States Bureau of Public Roads, discloses the average week-day traffic units to be divided in the ratio of 97.3% motor-driven and 2.7% horse-drawn. This result is quoted to indicate the degree to which, as rural pavement mileage is completed on the principal traffic lines of the State, highway transportation is measured in terms of the motor-driven vehicle. An adequate background, therefore, against which to project the discussions on highway transportation, is furnished by a brief résumé of the growth in the number of the major traffic units, motor vehicles, and the development of the roadways over which to operate these units. The proper combination of these two provides highway transportation, in a physical sense, characterized by the ease and speed with which it may be expanded and by the flexibility with which it may be adapted to a wide range of utility.

This Society is doing a real service in directing public attention, not to the component parts of highway transportation, but rather to the product itself. Table 1 is a comparative statement covering the eleven-year period, 1910 to 1921, which indicates the relative development of these component parts.

TABLE 1.

	1910.	1921.
Automobiles	487 000	8 404 000
Trucks	14 000	1 346 000
Totals	501 000	9 750 000
Maintenance fund	$ 25 000 000	$ 180 000 000
Construction fund	95 000 000	420 000 000
Totals	$ 120 000 000	$ 600 000 000

It is evident that highway development has lagged far behind the development of motor vehicles. This may be visualized strikingly by a comparison of the relative automobile registration and highway expenditures by years. The conclusions reached are:

1.—During the period, 1920-21, the potential number of motor vehicles demanding highway service increased more than 1 800%; while actual expenditures for highways increased about 400 per cent.

2.—During the period, 1910-18, motor vehicles increased more than 1 100%, and highway expenditures about 140 per cent.

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3.—During the period, 1918-21, motor vehicles increased about 700% and highway expenditures about 260% of the 1910 figures.

In fact, it was not until the Federal Aid Act of 1916 that the public as a whole undertook to support the building of highways on an adequate scale compared with the already existing users of the highways.

Since 1918 a large annual program of highway improvement has been carried on, and there is now the assurance of systematized development, beginning with the more important roads connected into a State and inter-State network, including not more than 7% of the total road mileage within each State. The total length of this proposed program will undoubtedly exceed 150 000 miles. The total mileage undertaken by the joint co-operation of the States and the Federal Government, on December 31st, 1921, had reached 35 500 miles, including all projects from those in the initial stage only, to those fully completed. This is the cumulative program of Federal Aid highways for the five-year period just ended, which includes the period of the World War. In the past six months, 7 533 miles of the various types have been completed. The estimated expenditure for 1921 of $600 000 000 was derived from the following sources:

Motor vehicle licenses	19 per cent.
State road bonds	7 " "
Local road bonds	33 " "
State taxes and appropriations	12 " "
Federal aid	14 " "
County, township, and district taxes, appropriations, and assessments	14 " "

This total expenditure was divided, approximately, $420 000 000 to construction and $180 000 000 to maintenance. More than 50% of the construction program was carried on under Federal Aid projects, bringing the control under both the State and the Federal highway departments, and, in addition, a considerable part of the remaining construction fund was handled under the direct supervision of the State, thus bringing probably about 80% of the total construction expenditure under the engineering control of centralized departments. This is contrasted with 27% of the total expenditure in 1916, which was under the control of the State highway departments. In the 26 years prior to 1916, a gain of about 1% per year, in securing control of the highway funds, was made by the State highway departments. Since 1916, the increase alone has amounted to more than 50% of the total expenditures. The Massachusetts Highway Department, in 1893, was the first highway organization to engage in administrative and engineering control of the design, construction, and expenditures made by the State for building highways. When the Federal Aid Act of 1916 was passed, about thirty-two of the States had established highway departments, having varying degrees of control and varying amounts of highway funds with which to work. In 1916 and 1917, however, in response to the demands of the Federal Aid Act, seventeen new departments were established and many others were strengthened and given larger funds. As a consequence, all the States are now carrying on their major work under the direct supervision of State highway departments,

and the supervision of the Federal Bureau of Public Roads extends in detail to all Federal Aid roads.

The typical State highway department is organized in two major divisions: Administrative and engineering. Quite generally the administrative heads are commissions, of which the members serve only part time and are responsible for the major policies only. This leaves the entire executive and engineering control to the engineering staff, under a chief engineer or commissioner. Thus, the highway engineering organizations have been developed with definite administrative functions as well as of construction and maintenance. In the average department the engineering organization engaged on the actual building of highways, is divided into sections of design, construction, and tests. In the order of their authority, is the chief engineer, district or division engineer, resident engineer, and inspector. An estimate of the number of engineers employed by the State highway departments in 1919 totaled approximately 10 000. The construction program has practically doubled since then, but the number of engineers has not increased in the same proportion. On these men depends the character of the construction which goes into the highways.

Inspection is broadly interpreted as the engineering control that must be exercised over the construction program to insure first-class results. The building of roads must be considered as a manufacturing process, undertaken where the roads are to be built, not where this manufacturing process can be most advantageously performed. The wide distribution of the contracts undertaken annually within the average State, and the conditions under which the work is carried on, demands the highest type of engineers. The closest estimates that could be made in 1919, indicated that not less than 1 000 to 1 200 new engineers would be required in the highway work each year. These men must be furnished by the engineering schools, and although there is a lack of employment at present, for engineers, generally, with the opening of the construction season, the road-building industry will be able to absorb and will need more than are available of those fitted to assist in producing the character of roads needed. As indicative of the training of men needed for the highway program, and the character of instruction which should be received in the colleges and universities, the following are suggestions:

1.—Human relations: The ideals of public service; proper contacts with the public; and proper relations with the contractor.

2.—Management: Laws—State and national; layout of plans; material supplies; transportation; estimates; contractors' obligations; and engineering and administrative reports.

3.—Construction proper: Design—Interpretation and relative values; specification interpretations; and workmanship.

4.—Materials: Interpretation of laboratory tests; field tests; and soils.

5.—Traffic management during construction.

6.—Relative values: Economics of highway transportation.

These suggestions are not to be interpreted as advocating the adoption in college and university courses of superficial specialized instruction, but the

curricula of the average engineering course should be and can be revised and broadened to give thorough training in some of the broad fundamentals of science, English, economics, and ideals of public service, in addition to sound courses offered in the Junior and Senior years, which will fit men to enter highway work much better prepared than they are at present. This responsibility, however, should not fall on the schools alone. The highway departments—State and Federal—must assume responsibility for bringing to the assistance of those in charge of engineering courses, contacts and opportunities of which those interested may avail themselves and thus obtain a correlation of theory and the practical application before graduation. The development of the short course for those already engaged in highway building, and of the graduate courses for research in special fields, are both of great importance in the advancement of engineering training and knowledge so seriously needed in the highway field to-day. The close correlation and co-operation of the highway departments with the educational institutions is greatly needed if the public is to be well served.

THE INSPECTION OF HIGHWAY CONSTRUCTION

By William G. B. Thompson,* Assoc. M. Am. Soc. C. E.

Considering the importance of the duties and position of the inspector in the general scheme of highway improvement, there is a singular lack of information, or attempt at analysis of the reasons, for his existence. Few, if any, of the highway textbooks refer to the inspection of materials or workmanship, although they elaborately set forth the other factors deemed to be important to the proper conduct of any highway project, both as regards the quality of the materials and workmanship and the manner of their combining to secure the desired result.

The "Definition of Terms" found in most State highway specifications defines "Inspector" as follows:

"A representative of the Engineer authorized to make all necessary inspections of work performed and materials furnished under this contract. Such inspection may extend to all or any part of the work and to the preparation or manufacture of the materials to be used."

Further, "Duties of Inspector" are outlined as follows:

"The Inspector is authorized to inspect all work performed and materials furnished. He shall report to the Engineer the manner in which the work is being executed and the quantity and quality of materials received and used therein. He shall inspect all materials as received and, when there is any doubt regarding the quality of the same, notify the contractor to this effect. No materials shall be used until approved by him. When he discovers that any work performed, or material furnished, is defective, or does not comply with the requirements of these specifications, he shall notify the contractor and the Engineer to this effect. In case of any difference of opinion arising between the contractor and the Inspector as to the materials furnished, or the manner of performing the work, the Inspector shall have the authority to reject the materials and suspend the work until the question at issue can be referred to and decided by the Engineer.

"The Inspector, however, does not have the authority to increase or decrease the quantity of work to be performed, change the location, alignment, or grade of any of the items of the work, issue instructions that are contrary to the plans and specifications, or accept any material or work that does not comply in every respect with the requirements of these specifications. The Inspector shall in no case act as foreman nor perform other duties for the contractor, nor interfere with the management of the work by the latter."

In addition to these duties, many departments require inspectors to sign monthly estimates and the final statement of cost, without which the contractor cannot receive payment at the completion of any project.

From the preceding, one might deduce that the inspector has almost plenary power, yet, in actual practice, his power and authority are so circumscribed and limited that, on many occasions, even the most intelligent men are at a loss as to the proper course, and find themselves more or less of a nuisance in the eyes of the contractor; something to be endured possibly, and cajoled but never, or rarely, to be taken seriously. That this attitude on the part of

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the contractor exists in hundreds of instances, no one familiar with the conduct of highway work to-day will deny.

To what is this state of affairs due? Wherein lies its claim on the interest and attention of this Society, and what is the remedy?

It is due to various causes, many of which have their origin in the beginning of public works activities, and is a curious commentary on the frailty of human intentions, particularly as applied to the conduct of public improvements. One might reasonably expect that, given a clear plan of the work to be performed, a clear statement of the quality and quantity of materials to be used, and a clear statement of the manner of their combining and use to effect a completed structure, the contractor could, and should, without inspection, deliver a completed structure complying with the requirements given him.

If such a method were ever tried, it evidently failed to meet expectations, and there resulted the appointment of an inspector, whose function was more that of a policeman or detective than as an interpreter of the specification requirements. Thereafter, as public works increased in extent, the power of appointment to the position of inspector frequently became a political asset. He was placed on the work ostensibly to protect the public interest; actually, in many instances, he became the medium through which unscrupulous public officials and contractors mulcted the public treasury.

Even in this day, instances are not wanting where shoemakers, saloonkeepers, and others, having no knowledge of, or experience in, construction work, are placed as inspectors to satisfy political debts or to build up and perpetuate a political machine.

Other causes, such as low pay, uncertain tenure of office, lack of opportunities for advancement, and the necessity of moving from place to place, have contributed to the existing lack of able, experienced inspectors, which, in turn, gives rise to the lack of mutual respect and harmony, too frequently found to exist between the contractor and inspector; although it must be admitted that conditions in this respect are far better than they were a few years ago, and there is a notable trend toward further improvement.

Therein lies an opportunity for the Society, collectively and through the efforts of its individual members, to render a signal service to the country by the appointment of a committee to investigate this subject thoroughly in all its phases, and to prepare and submit a report, recommending a course of procedure for the inspection of public works contracts, which, perhaps, would be a modification of the present most advanced procedure, with improvements, but which should be drawn so as to eliminate, from future practice, the present uncertain status of the inspector.

The Society is vitally interested in this subject, because, to an increasing extent, the men who are to be its future members, get their first practical experience, after graduation, as inspectors. Obviously, they can have had but little experience or knowledge to fit them for the position, with its inevitable contacts and influences.

It is submitted that the preparation of papers and discussion in the abstract of matters which bear particularly on the relation of the engineer to public

works will avail very little unless they are considered as problems to be acted on; and the prestige of the Society or any of its members are only hollow triumphs if they are not used and exerted for the common welfare at every possible point of contact.

To-day there is not, nor will there be for many years, any other public activity in which engineers are interested, which compares in extent and moneys involved with the highway and street paving movement. Neither is there any other public activity in which the destructive or deteriorative agencies follow so closely on the attempts of the engineer to build against them, as is the case of the highways and the heavily loaded, high-speed vehicles which use these highways and streets.

Research and testing are disclosing much, but the art of highway building has a long way to go before even the best specifications and the strictest observance of their requirements will deliver the road, proof against the assaults of the trucks. Is it not, then, of paramount importance that the most rigid compliance is secured with the specifications, requirements which present limited knowledge enables engineers to prepare; and in no way can this compliance be insured, except through the inspector who is the point of direct contact between the chief engineer and the contractor, and who is directly responsible, from the public viewpoint, for the integrity of the finished product.

The Panama Canal was the largest public enterprise prior to 1916. The Government was ten years in finishing it, at a cost of $350 000 000 or $375 000 000. At the present rate, $5 000 000 000 or $6 000 000 000 will be spent during the next ten years for highway and street construction and paving, and highway bridges; and as the plans, specifications, materials, etc., are more or less fixed quantities, the unknown quantity is the inspector, since he, primarily, is responsible.

This does not assume that all contractors are dishonest, *per se,* or indifferent. Most contractors are honest and have a fine pride in their work, but the great amounts of money to be spent, attracts, along with the honest men, others to whom this work looks like "easy money".

How is the condition to be improved or remedied?

First.—As citizens, engineers should endeavor in their several communities to eliminate that curse on public works, political appointment, made without regard to ability, fitness, or integrity.

Second.—Through its members who are highway engineers, or who are engaged in highway work, the Society should exert the utmost influence against the appointment of inspectors, except for ability, and by training, example, and precept, should raise the standards and ideals of their men. Some highway departments now have winter schools for their men, which are attended by inspectors during the slack season for one or two weeks, while under pay. These are good, and their establishment should be encouraged.

Third.—Provision should be made for the retention of inspectors at full pay through the slack months. If they are worth having during the construction season, they are worth keeping and paying through the winter. Much more is eventually lost to the public by engaging new, untried men every spring, than by paying an efficient corps for three or four months of the winter,

and acquainting it with the results of research and knowledge gained during the year.

Fourth.—The importance of the inspector's position should be generally recognized; and his compensation and employment made as attractive as possible.

Fifth.—Assuming the existence and maintenance of a corps of trained, capable engineering inspectors, the status and authority of the inspector's position should be more clearly defined, and instead of limiting his authority, it should be extended to permit of his making prompt decisions on the ground, thus eliminating the delay and financial loss to the contractor, which now frequently results when the engineer is unable to reach the job for several hours after any dispute arises.

Sixth.—It should be generally recognized that material producers frequently ship materials which do not comply with the specifications, thus causing delay and conflict between the contractor and the construction inspector. Differences between contractor and job inspector, and consequent delay and antagonism due to this cause, can be eliminated entirely by placing competent inspectors at points of material production to inspect and approve all shipments before they are billed. This method, if consistently followed, will eliminate one fruitful cause of conflict.

Seventh.—Many of the highway inspectors to-day are engineering graduates, and, as such, are potential members of the Society.

The matter of the appointment of a committee to investigate and report on the subject of highway inspection might well be considered and an attempt made to raise the standards of inspection, with its incidental benefit to future members and to the highway program of the Nation.

FINANCING AND BONDING HIGHWAYS

By John N. Cole,* Esq.

Vital as transportation has been in the development of every nation, it has reached its highest place of importance in the development of the United States.

Transportation has followed along many paths of development, and it would seem as if out of all the experiences in the transition from the Pilgrim methods of intercommunication to the present types, something should have been learned as to the relation which each period should bear to the other. This is peculiarly true as to the problem of the wisest method to be adopted in undertaking the development of the new form of transportation as it now calls for consideration, but perhaps with no phase of such development have the American people been willing to profit less by past experience than in this particular problem of wise financial handling of the present-day situation.

The earliest transportation systems in Massachusetts, which may perhaps properly be called the virgin soil of America, required little capital outlay with such development work as was undertaken. When the first highways were undertaken, the private owner cut the trail and built the ford which afterward was replaced by the bridge over which he alone or with his associates, for a long time, exacted toll—all again without any reference to the problem of how the developed system of transportation should bear on the general community.

The more intensively developed agencies for transportation that have followed from that day until 15 to 20 years ago, gave hardly less heed to the future than these earliest agents, because the constantly developing new territory, and the rapid unfolding of the broader field to be served, afforded what appeared at that time to be unlimited opportunity for issuing securities on money invested and against labor performed, sometimes real and too often imaginary, on which dividends or interest charges could be easily placed and with little difficulty paid under a real or assumed earning, but too often produced out of new capital provided.

Then came the stock taking. The public no longer absorbed new securities for railroads, or undertook development of street railway lines having inception only in the fertile brain of the agile promoter. The development of the automobile caused the student of transportation securities to become seriously concerned over not only the problem as it then existed, but the future conditions that should control the work of placing the greatest factor in National civilization—its transportation interests—on firm and substantial ground.

From that time until the present, transportation facilities have been in a chaotic state which has been made more so by the demand for improved highways. The motor vehicle is a return to individual service, and because it is an individual service it is the popular service.

So long as highways were called upon to bear a small load, hardly ever exceeding a ton, and at a slow speed, with freight almost a negligible quantity,

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the problem of constructing a surface that would fairly well carry the load was not difficult. Also, as long as the general public was satisfied that, in the spring, the coming out of the frost might leave a highway unfit for travel, it was still less difficult.

The motor vehicle has changed all this, and pages might be written to tell of how it has been changed, without having anything presented more effective than to call attention to a result of the traffic census in Massachusetts, which has been taken biennially for many years. Selecting the same forty-four stations for a traffic census to show the movement and the development of freight per hour during the last twelve years, the figures in Table 1 are given.

TABLE 1.—Traffic by Weight, in Tons per Hour.

Year.	Horse.	Automobiles.	Auto trucks.	Total.
1909......	200	160	....	360
1915......	140	840	180	1 140
1921......	70	3 500	1 260	5 530

Could any statement present more clearly the changed conditions under which highways must be constructed to care for the modern demands for motor transportation, unless to present a further statement to show the tremendous increase in the public dependency on motor transportation, as given by the registration figures of motor vehicles in Massachusetts for use on January 1st, 1922, as compared with January 1st, 1921? Massachusetts compels every motorist who wishes to operate his vehicle on January 1st to be registered and carry his new number plates on that day. This rule has been strictly enforced for three years. Acting under it, there were registered for use January 1st, 1921, less than 80 000 vehicles, and on January 1st, 1922, there were more than 140 000 vehicles. In 1921, before the close of the year, the 80 000 vehicles in Massachusetts had increased in number to 350 000. In 1922 it is estimated that the 350 000 of 1921 will have reached 420 000, a natural increase of 20% for the year, but the figures for January 1st show an increase of almost 100% in dependency on the motor vehicle for every day service. This enormous growth of the motor vehicle is duplicated in every section of the United States. On the part of owners and operators there is a strong feeling that already motorists are contributing their full share to the problem of building and maintaining the ways on which they must operate to give their full measure of service, but the figures show that it is their job.

The nation becomes each day more dependent on this particular type of transportation. The construction of modern highways to-day is failing to keep pace with the demands. The competition between communities is more than a community pride; in many cases, it is a struggle for the existence of the community now entirely dependent on motor transportation. The speaker could cite case after case in Massachusetts where the only way out for resident and business is that provided by the modern highway and the motor vehicle. To meet this situation is the task. How to pay the bill is the problem. It is a problem that cannot be freed from its relation to the cost of all previous

systems on which there has been a capital outlay and it is vitally related to the cost of all future systems.

As a problem that cannot be freed in its consideration from the cost of previous systems, it requires careful study from the standpoint of how much destruction of previous capital outlay is justified in connection with expenditure for this new system.

Duplication of service is always uneconomic. The substitution of a more efficient form of service for one that has become inefficient, is always wise.

It is not new for the development of one type of transportation to destroy the investment in another. An example of fixing railroad rates so that long established and efficient waterway transportation has been eliminated, even though naturally a better service and more economically conducted, should lead us to go slowly in allowing this new system of motor transportation to bring about the same result in connection with either the developed waterway service or the long established railroad service, for with both of these systems it must be wisely co-ordinated.

Much more important, however, than this phase of the situation is the enormous dependence that National life and world life must continue to place upon railroad service. A sound burden for the public to carry frequently calls for continuing several types of transportation if full service is to be secured, and the need of destroying old capital investment at the expense of the public must be recognized as a condition that must be frequently faced in changing from the old, unsatisfactory and uneconomic service to the modern system of motor operation. If this means a double burden, it frequently spells a complete service.

This brings up the second fundamental problem in relation to the cost and how that cost should be borne in connection with a future system. It is clear that if, at the outset, the public pays in a direct charge for motor transportation and in an indirect burden which an abandoned system still places on the public, because bonds have not been paid and because investment still is there, the original load has practically been doubled.

Another phase of the future, that must never be lost sight of, is the constant increasing cost placed upon the public at large, for investigation, study, and research for a new system yet unknown but sure to come, for "the old order constantly changeth".

Practically every highway in the United States in existence fifteen years ago made up a possession of the people of a value impossible to compute. In Massachusetts the 23 000 miles of highway represent a property investment exceeding $20 000 000 in value. This came to the people in 1905 unincumbered, capable of further development, ready for such improvement as has since taken place. In meeting the needs for better roads the nation has spent in that 15-year period, not less than $1 000 000 000 per year, and to encourage the development of a system of through routes has undertaken a program of bond issues that represent a total debt to-day in excess of $1 000 000 000. More than that sum has been placed on cities and towns to pay, and all of it will come due from 10 to 50 years hence, with more and more added every year.

TABLE 2.—BONDING OF HIGHWAYS IN THE UNITED STATES.

Issues are for periods ranging from 10 to 50 years.
Amount of issue under 20 years, $114 790 000.
Amount of issue 20 to 50 years, 922 085 500.

State.	Date of issue.	Authorized.	Unconstitutional or deferred.
Alabama	1920	$25 000 000	$25 000 000
California	1910-19	37 000 000	....
Colorado	....	5 000 000	5 000 000
Connecticut	1907-13	10 000 000	....
Florida	....	20 000 000	20 000 000
Idaho	1906-20	2 705 000	....
Illinois	1918	60 000 000	....
Iowa	....	100 000 000	100 000 000
Maine	1912-19	5 000 000	....
Maryland	1908-20	24 470 000	....
Massachusetts*	1894-1917	20 050 000	....
Michigan	1919	50 000 000	....
Minnesota	1920	75 000 000	....
Missouri	1920	60 000 000	....
Montana	....	15 000 000	15 000 000
Nevada	1919	1 000 000	....
New Hampshire	1909-13	1 300 000	....
New Jersey	....	20 000 000 (for tunnel)	....
New Mexico	1920-21	2 000 000	....
New York	1906-12	100 000 000	....
North Carolina	1921	50 000 000	....
Ohio	....	50 000 000	50 000 000
Oklahoma	....	50 000 000	50 000 000
Oregon	1917-19	30 500 000	....
Pennsylvania	1918	50 000 000	....
Rhode Island	1907-20	1 800 000	....
South Dakota	1919	6 000 000	....
Texas	....	75 000 000	75 000 000
Utah	1911-21	5 260 000	....
Washington	1911-20	30 190 000	30 000 000
West Virginia	1920	50 000 000	....
Wyoming	1919-21	4 600 000	....
	....	$1 036 875 500†	$370 000 000

* No bonds have been issued for highway construction in Massachusetts since 1917, and all bonds issued since 1913 have been for the layout and development of roads in the sparsely settled sections of the State, to bring outlying towns into touch with the larger communities. There is outstanding at the present time a little less than $5 000 000.

† Entire issue for construction, with the exception of $100 000 000 in Western States, which covers construction and maintenance. Of these bonds, $417 500 000 was issued in 1919, 1920, and 1921.

From Table 2, it will be noted that hardly a State in the Union is free from this system of relying on future generations to pay for present expenditures. Each year will add to this enormous total, and unless the public compels itself to appreciate the seriousness of this load, and unless there is a determination on the part of each community to pay the bills of the present out of the revenue of the present, serious times are ahead. It must be recognized:

(*a*).—That there is no such thing yet discovered as a permanent highway.

(*b*).—That each generation brings forth new peculiar problems and operations.

(*c*).—That no demand in any community in 1922 is any less than that in 1921, even though the demand seemed to be answered in 1921.

Many of the bonds issued by the States represent burdens not to be relieved for 40 years. Not a highway in the United States completed to-day and paid

for out of such a bond issue will be in existence at that time. New lines of travel will then be established. Enormously increasing demands will have been created. Different types of service will be seen from every angle. The vision of the human mind is unable to furnish anything permanent enough to stand the test of a 40-year period.

The speaker may well take pride in the position that Massachusetts holds to-day in connection with this problem. She was the first State to begin the development of the improved highway. Like most States that have followed, she yielded to the pressure for an expenditure of more money than any single year could provide. Little by little the amount grew until a large sum had been placed against the credit of the State for this improvement.

In 1917 the end came. Since that day no bonds have been issued and during the period between 1896 and the present, the bonds have been retired leaving the Commonwealth of Massachusetts a little less than $5 000 000 in debt for this type of public improvement.

Not only has the State gone on a "pay-as-you-go" policy for itself, but by statute it has made it impossible for any city or town to borrow for more than five years, money for highway improvements, and for this five-year period no money can be borrowed unless specifications for highway construction conform to the standard fixed and approved by the State Department of Public Works.

The situation is largely due to the increased revenue coming to Massachusetts as it has practically to every State in the Union, from the registration of motor vehicles.

It has been recognized and is firmly believed that the motor vehicle has created the problem and the motor vehicle should pay the bill. The figures given in Table 1 relative to the movement of freight at forty-four different points on the same day in three different years, clearly demonstrate that the burden placed on the highway is insignificant so far as every other form of vehicle is concerned, except the motor vehicle. For motorists to refuse to pay, is, from a Governmental standpoint, unsound, and from the standpoint of the motor industry, most unwise. Again, the speaker would state that the financing of the modern highway is the motorist's job, to be done to-day for to-day.

The enormous problem of rebuilding and making available nearly 200 000 miles of important highway in the United States, has hardly begun. The billions of dollars that would be necessary to realize that dream must be provided, but should be expended only as they are available from year to year.

The American people can no longer afford to fool themselves in the belief that they are building for the future when they are building modern highways. The problem of to-day is for to-day's solution. In no line of public work is that more evident than in the construction of the service which the highway must render to this newest type of transportation created by the development of the motor vehicle.

HIGHWAY BONDING FROM THE VIEWPOINT OF THE SURETY COMPANY*

By E. A. St. John,† Esq.

Surety companies are looking forward to a large volume of this business. Many of the States have extensive programs, with the money available or in prospect. The National Government has appropriated $75 000 000, which will be used jointly with an equal amount appropriated by the several States. There should be an enormous increase in highway contract bond business during the next few years.

These contracts are really financial guarantees: First, that the contract will be performed; and, second, that all claims in connection with it will be paid.

Surety bonds should be issued only to specially selected applicants. There is involved: First, the adequacy of price; second, ability to do the work; third, reasonable and practical specifications; fourth, fair supervision; fifth, financial responsibility of the contractor; and, sixth, moral honesty.

Specifications should be prepared free of ambiguities so that every condition will be readily understood. The contractor has no voice whatever in the specifications—the engineer is made the sole judge of their meaning. Anything misleading, therefore, should be avoided.

The contractor takes practically all the risk of unforeseen conditions, unforeseen physical hazards—the risk of strikes and increased wages, of securing the necessary materials and paying increased prices for them, and of overcoming all conditions—he must do the work!

The highway department, in the performance of its duty, wants the work done at as low a price as possible, consistent with good workmanship and material. The contractors submit their bids in competition, some with the one thought in mind, namely, to calculate close and get the job; others calculate high, with the chance, perhaps, that their bid might be low by accident, and this sometimes happens. Although the average bid probably represents the fair price for a given job, it is not the average bidder who gets the work, but the lowest bidder. Not infrequently at the opening of bids a surety company will find itself on the bond of a bidder whose figures are so much lower than the average that no other company will accept any part of the risk as reinsurance. This causes considerable uneasiness, particularly if an underwriting point were strained when the bid bond was authorized.

Barring the rare cases where a dishonest contractor robs the job and absconds or uses the money for some outside venture, the safety of the surety company is purely a question of whether the contractor can complete his contract and pay his bills, whether he can do it within the contract price, and if not, whether his own resources will hold out.

The surety company is interested in seeing that the contractor gets a fair contract, that the specifications are just and reasonable, that the price is fair,

* In the absence of Mr. St. John, this paper was presented by the Hon. Francis M. Hugo, Watertown, N. Y.

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that he is given a decent and fair supervision by the engineer, and that he gets fair treatment in the interpretation of the specifications.

Contracting is a hazardous business; therefore, efficiency is imperative. Good management wins; the skill to calculate the cost of a job accurately, the foresight to make contracts for materials with responsible concerns, and the ability to buy at the lowest prices.

Contractors and, indeed, engineers sometimes feel that the surety companies do not give enough weight to experience and ability, but rely too exclusively on the contractor's financial statement. The basis for underwriting is this: Give a clean record to a contractor who has requisite ability, the necessary plant, organization, and equipment. With no extraordinary variance in the bids, he must also have a margin of available cash, or equivalent, not only to finish the work, but to take care of the ever-present danger of loss from unforeseen contingencies. This margin is about 10% on simple non-hazardous contracts, and goes to 20% on the extra-hazardous classes of work. This is the requirement when conditions are favorable. If the bids are out of line, if money must be expended for plant, if the contractor is without particular experience in this line, or has no record for efficiency in the handling of his work, a higher ratio of financial resources is required.

The underwriting of the particularly large volume of highway business in prospect is not as free from difficulty as some contractors and underwriters are prone to think. Contractors, hungry for work, are calculating close, apparently anticipating still lower labor and material prices, or willing to take a small margin of profit to keep their organization employed. This is dangerous, not only for the contractors, but for the surety companies as well, because when this tremendous program gets under way, there is likely to be a reaction upward in prices for both labor and materials; such a reaction would accord with normal economic experience. There is, of course, no likelihood of repeating the great crisis reached during the 1917-19 period, but there is likely to be at least enough reaction to wipe out the small margin of profit that some contractors are now calculating. This would reduce tremendously the margin of safety for the surety. If luck goes a little against the close calculator who went after the contract to get it in order to keep his organization employed, he may have a hard time to make both ends meet, and if things go badly against him, the surety company may have to complete the job and pay the bills.

A particularly hazardous feature is when maintenance guarantees are required, for in that case the continued financial responsibility of the contractor is involved, as well as his knowledge of the various kinds of surface pavements, and their suitability to climate and traffic.

No feature is of greater importance than that of availability of the contract price or the earned retained percentage as security for the surety where it is compelled to pay material claims incurred by the contractor, and this involves the financial relations of the contractor to the banks and to money lenders. Where the contractor, in order to borrow money, assigns the estimates and retained percentages to the lender, it has been held in some States

that the latter take these moneys in preference to the surety company that pays the material claims.

The contracting business is inherently hazardous. Some of the ablest men engaged in the business, after making big successes, have failed. The president of one of the prominent surety companies is reported to have said that few contractors or contracting firms have a record of more than twenty years—most of them fail within that time.

It is convenient for a contractor to be able to furnish a surety bond. It takes nothing out of his surplus, except the premium, enables him to recover his "good faith" check, which accompanied his bid, and places him in a position where he can avail himself of all his assets and resources in the performance of his contract.

As compared with any other known practical method, it is economical to furnish a surety company bond. The alternative in New York State is a higher percentage of retention, and, also, the retention of the check deposited with the bid, until 15% of the contract is performed. Should 15% of the contract not be performed, the check is forfeited as liquidated damages. Without a bond, the increased percentage of retention applied to a contract of \$100 000 works out about as follows: Assume for the purpose of discussion that a contract is performed in four equally productive months; of the \$25 000 worth of work performed, the contractor would receive at the end of the first month \$20 000, and about this time his \$3 000 bidder's check (3% of the contract price) would be returned. To the time of the payment of the first estimate, therefore, the contractor would be deprived of the use of his \$3 000 deposited with his bid, which would not be the case if he had given a bond. In addition to the \$3 000 thus held, there would be \$5 000 deducted from the first estimate, so that if the \$3 000 were not considered at the moment of the payment of the estimate, which is likely to be the case, the State, at that time, would be holding \$8 000 of the contractor's money, on a \$100 000 contract, of which only 25% had been completed. Carry the illustration through the contract: Assuming the return of the \$3 000 deposit check soon after the payment of the first estimate, the contractor would still have not less than \$5 000 of his earnings of his first estimate held by the Highway Department, and an equal amount of \$5 000 would be deducted from his second estimate, so that at the half-way point, the contractor would be deprived of \$10 000 of his earnings. At the end of the third month, it would be \$15 000, and when the contract is finished and he is still waiting for the final estimate and payment, he would be deprived of \$15 000, plus the gross estimate for the last month, or \$40 000 in all, having received from the State not more than \$60 000 on a \$100 000 contract.

Contrast this situation with the advantages of giving a surety company bond. When a bond is given, not only is the \$3 000 deposit check made available for the contractor's use, but he is entitled to \$90 000 of his estimates, which makes a material difference to the contractor in the amount of money with which he is to operate, and may well mean the difference between success and failure in the performance of the contract, since many contractors fail by reason of money shortage. It can be seen that the payment of the small

premium required for a surety bond is only a small matter, compared with the greater advantages to the contractor in having the use of his money.

In regard to service in times of difficulty: Where corporate sureties are interested as sureties for contractors, it sometimes happens that by reason of the interest of the sureties, and the co-operation between the contractors and the sureties, the contractors derive a material advantage. This is well illustrated in the work which brought about a very equitable statute passed by the New York State Legislature and approved by the Governor in 1919, commonly referred to as the "Knight Bill". By reason of the unusual conditions arising from the declaration of war by the United States, the fulfillment of highway contracts by the contractors was made difficult and, in most cases, rendered impossible. The prices of labor and material soared to prohibitive heights, and neither was available in sufficient quantity or quality to perform the contracts then outstanding, some of which had not been started and others of which were in various stages of completion. There were, perhaps, 250 or 300 of these contracts, varying in amounts from \$20 000 up to several times that amount.

For the State to have attempted to enforce the contracts, without any relief whatever to the contractors, would probably have resulted in bankruptcy for 90% of the highway contractors in the State. The reaction would probably have resulted in long and tedious litigation of all these contracts or the greater part of them, paralyzing of the State highway work within the State and practically depriving the State of the opportunity of availing itself of the skill and experience of a majority of these contractors, which, in itself, would have been a distinct loss. In that situation, the sureties took an active and, indeed, a leading part in gathering data, analyzing the situation, and presenting the problem to the Legislature and other officials in Albany, which resulted in the passage of the Knight Bill. This bill provided that the State should pay a dollar for a dollar's worth of work at the time of performance, which, in view of all the circumstances, was the only equitable and fair thing to do. It also provided for the cancellation, as of April 6th, 1917, the date of the declaration of war, of all highway contracts then outstanding and uncompleted, in which there had been no default other than the failure to complete; and to those contracts that had been partly performed in 1917 and subsequent to April 6th, and in 1918, it provided for reimbursement to the contractors of the excess cost of such work in 1917, not to exceed 35% of the price of labor, materials, and transportation, and for 1918, not to exceed 50% of the price of labor, materials, and transportation thereof, to be determined by an action and hearing before the Court of Claims.

It is doubtful whether the contractors, without the co-operation of the sureties, could have achieved this result. Although it cost the State some money to make provision for the increased cost and the re-letting, the State paid only what the work was worth at the time it was done, and probably paid less in the end than it would if the contractors had been forced to go through with their contracts as far as they could. This was an unusual situation, arising from circumstances over which neither the contractor nor the State had control, and which could not have been foreseen by either, but it

serves to illustrate the value of the service of the sureties in emergencies and under unusual circumstances. All three parties profited—the State, the contractor, and the sureties.

Now, let the matter be considered briefly from the standpoint of the surety companies. Some wonder has been expressed by contractors who are compelled to pay the high premium charges for contract bonds. If the underwriters of surety companies were endowed with the necessary wisdom to select contractors with unerring judgment, they could in practice, make the writing of bonds what it is in the theory, namely, the rendering of a service—the selling of the use of the name and credit of the company for a specific purpose and for a specific price—that is what the surety companies strive to do, and if they could succeed, it would be necessary to charge only enough to pay operating expenses, plus a small margin of profit. In practice, it does not work out that way. The underwriters make mistakes. They bond contractors who fail, and, by the same token, they turn down contractors who finish the job. The companies select the best underwriters they can find and give them the benefit of all the statistics they have, and notwithstanding they have every incentive to separate accurately the "sheep from the goats", they make mistakes. The result is that the companies sustain large losses and find it necessary to charge a premium which will not only pay their operating expenses, plus a small margin of profit, but also pay the inevitable losses. It is to the interest of all concerned to keep these losses at a minimum—the lower the loss ratio the lower the rates. The average rate to-day for construction bonds is 1½% on the contract price. It, therefore, takes 75 bonds to produce in premiums an amount equal to the average contract, but approximately one-half of the gross premium goes for various expenses; it, therefore, takes 150 separate risks to produce enough net premiums to pay one total loss. The odds, therefore (assuming the loss to be a total loss), against the underwriter, are 1 to 150. The average loss, however, is less than the full amount of the contract.

The surety companies are hopeful that the experience during the next few years will be better than it has been during the past three or four years; and if such experience justifies it, there can be no doubt that a reduction in rates will follow.

It is much easier to lay down rules than it is to apply them. In the first place, it is difficult to get accurate and complete information. Many financial statements are in round figures and difficult to verify. More or less dishonest contractors, and more or less dishonest brokers, have learned to deceive the underwriters of surety companies. Picture an agent of a surety company pilgrimaging to the capital of a State to be present at the road-contract letting, meeting the contractors there, ready to bid, escorting them to a local bank and arranging to give the contractor the necessary certified check to accompany his bid on the written agreement that should he prove to be the lowest bidder, the surety company would sign the final bond; then consider, further, the ludicrousness of a man without any experience whatever as a road contractor, without any financial responsibility, and therefore, of course, without any plant, submitting a bid without going through the formality of making any figures, but, accepting the engineer's estimate as a reasonably

safe figure, submitted it with the certified check arranged by the surety agent, and, then, proving to be the lowest bidder! Up to this point, his plan had worked out. His thought was that one of the other contractors would buy the contract, yielding him a profit, but his bid was so low that no contractor would have any of it. That is the position in which a surety company found itself, and it provided a contractor to do the work with considerable loss to itself. Competition among the surety companies is almost as keen as it is among the contractors.

We have spoken about "busted" contractors. The mortality among surety companies has also been high. The United States Treasury Department, for years, has issued a quarterly bulletin showing the amount for which the respective companies can qualify on a given bond in favor of the United States Government. There are about as many companies listed on this bulletin to-day as there were a dozen years ago, but, to-day, one will not find more than five companies so listed, that appeared on these bulletins a dozen years ago, which means there are just five of them left. It is well known what caused the failures of these companies—it was principally poor contract underwriting. Something has been learned from these dead surety companies, but there is still much to learn.

In his opening remarks the speaker stated that surety companies looked forward to an enormous volume of highway contract bond business. It will be the purpose of surety companies to co-operate with highway commissioners, their engineers, and their contractors, to give good service, and to co-operate in every way possible to the best interests of all concerned.

FINANCING AND BONDING HIGHWAY WORK

By Edward C. Lunt,* Esq.

The speaker will try to show how surety companies underwrite highway bonds; that is, how it is determined whether or not they can prudently issue them. The first thing to be considered is the contractor's financial condition. If his resources are found to be slender compared with the size of the job, that fact seems almost fatal in itself, without regard to any other considerations.

Although underwriting methods in general are freely criticized by agents, contractors, engineers, and highway commissioners, this particular item in the underwriting creed, the insistence on financial responsibility, receives more than its share of disapproval. For example, the surety companies are naturally pleased when it is found that an applicant for a highway bond is not only a contractor of the usual type, but also an engineer; but even that favorable factor seems to them not to supersede the necessity of financial resources commensurate with the magnitude of the given job. Not all engineers are richly endowed in that respect, and sometimes these engineer-contractors rather resent the application of sordid considerations of this kind to their cases.

Surety companies regard a strong financial condition as a *sine qua non* of bondability. They like to feel reasonably certain, not only that the contractor will be able to finish the work by reason of his equipment, plant, experience, and general capacity, but also that he has sufficient financial resources to tide him over any of the numerous mischances to which his hazardous calling is subject. They like to feel confident that it will not mean loss to him and to them if, through some contingency unforeseen and perhaps unforeseeable, he finds his labor costs rising beyond all calculable forecasting, or if, at some critical stage of his contract, a freshet sweeps down the valley, ruining his half-completed work and turning his costly equipment into so much junk. Under such distressing conditions, nothing but solid surplus assets stand between the surety company and heavy loss.

If the unfortunate contractor is able to qualify for suretyship, as to this first requirement, the underwriter next considers the man's experience in the given line of work, his plant, equipment, etc. If the contractor has been engaged for years in highway construction and has been reasonably successful in such work, the surety companies are satisfied; but if it is found that he is just starting in business, they wonder whether his inexperience may not handicap him seriously and may not ultimately make them his partner or, perhaps, his successor in the given job. They fear that he will be like that other contractor, a bridge builder in that case, who found himself in desperate circumstances and knew that he must fail unless he could secure an extension of a large loan about to mature at his bank. When the president of the bank absolutely refused to renew the loan, the contractor asked him whether he had ever been in the bridge-building business. "No," he replied, "of course not." "Well," the contractor added, by way of breaking the news gently, "you

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are in it now." Similarly, underwriters sometimes find themselves plunged with equal abruptness into some mysterious and difficult business for which nothing in their previous experience has prepared them in the least.

A third underwriting point that is deemed of prime importance is the matter of other work on hand. If it is found that an applicant for a bond already has a number of big jobs under way, in various stages of completion, the underwriters are not over-enthusiastic about his case. Many contractors are too ambitious, they want to get rich too fast, and they undertake a great deal more than they can thoroughly accomplish.

Two or three points for which engineers are directly responsible have an important bearing on the decisions of surety companies. When engineers provide that the contractee shall be privileged to withhold a certain percentage of the contract price as the work progresses and after the completion thereof, as a protection against liens and undiscovered defects, they are incidentally benefiting the surety company, and the company is correspondingly grateful. Such a provision in the contract has often saved the company from loss. It is quite another story when, on the other hand, engineers include in their specifications penalties for delayed performance and maintenance guaranties. Underwriters regard maintenance provisions in highway contracts as altogether unfair to contractors. Performance and maintenance guaranties are reasonable, no doubt, in connection with the sale of machinery, patented devices, and the like; but they seem to be illogical and unjust to the contractor where the latter undertakes only to do a certain piece of work in exact conformity with detailed specifications laid down by the contractee. Under these conditions, responsibility for results would seem to rest logically with the framer of the specifications rather than with the contractor who merely carries out such specifications. When an engineer prescribes the precise manner in which a highway shall be built, it would seem to be no affair of the contractor whether the resultant highway stands up under the traffic for six months or six years. In the case of road contracts, maintenance provisions seem particularly unfair to the contractor both on general principles as indicated, and because a road designed for and normally subject to comparatively light traffic, from unexpected causes, may be forced to carry continuous heavy traffic during the maintenance period.

It may be questioned why the speaker has not included engineering considerations in his list of underwriting factors. There are good reasons for that. Because of the vast variety and number of bonds that must be disposed of with despatch, underwriters have no time, even if they had the ability, to consider them from an engineering point of view. In a single day a contract underwriter will pass on one hundred or more important bonds—bonds guaranteeing the construction of a big office building, say, a huge coffer-dam, a concrete viaduct, a 30 000-ton steamer, and a union station somewhere, perhaps all intermingled with filtration plant, dredging, and tunneling contracts, and a dozen or more big highway awards. How could any underwriter possibly apply in a single day engineering tests and standards to a situation of that kind, except in the most superficial way? From the nature of the case, the great

bulk of the business must be underwritten from a banking, rather than from an engineering, point of view.

The speaker hopes that he has somewhat indicated the determination of the surety companies to follow conservative practices in respect to highway bond underwriting. They deem such a course best for the contractors, the highway department, and every one concerned, for numerous reasons and, especially, because it tends to keep the business in the hands of competent and responsible people. Every interested party is anxious to have the work let to responsible contractors, to have it done on time, and in rigid accordance with the specifications. In the speaker's opinion these vitally important ends are directly and efficiently promoted by careful and prudent underwriting on the part of the bonding companies.

THE MOTOR VEHICLE IN HIGHWAY FINANCING

By Harry Meixell*

It is estimated that, during 1922, the United States Government, its States, the counties within the States, and the municipalities within the counties, combined, will spend fully $1 000 000 000 for highway purposes. These purposes include carrying and amortization charges on outstanding highway bonds; expenses for the administration of highway departments; maintenance of highways; construction of new highways; reconstruction of outworn highways; and the regulation of highway traffic.

Such a vast expenditure has been made necessary and desirable because of the insistent and justifiable demands of 10 000 000 motor vehicles for a wide-flung network of stronger and better highways, amalgamated into co-ordinating National, State, county, and local systems. More important than this is the fact that these vast expenditures have become necessary and desirable, because only through them can the maximum economic development of the country be achieved. No matter what one may think or say regarding the relative importance of the various mediums of transportation, highways are always the immediate stems on which farms, factories, stores, and homes hang as leaves, taking nourishment from and giving it to the whole tree of economic growth.

Notwithstanding the importance of highway transportation and the overwhelming part of the motor vehicle in it, law-makers have been too prone to take the position that highway improvement confers special, and as some would have it, exclusive benefits on the motor vehicle. In consequence, they insist that it should bear the entire burden of public highway financing. In other words, they would have the 10 000 000 motor vehicles now registered in the United States pay for the privilege of operating on the highways, the $1 000 000 000 which has been estimated will be spent for highway purposes in the United States during 1922.

Before discussing the merits or demerits of this contention let us examine briefly the registration fees, gasoline taxes, wheel taxes, and other forms of impositions which motor vehicles now pay into public treasuries, and, on these as a basis, seek to estimate what portion of the $1 000 000 000 highway program for 1922 the motor vehicle will finance. After that, an effort can be made to determine what portion it should pay.

The latest figures available on the subject are those which cover the year 1920,† as follows:

Federal:

1.—Passenger car excise taxes....................	$83 600 294	
2.—Commercial vehicle excise taxes...............	15 160 456	
3.—Parts, accessories, tires, excise taxes...........	49 960 128	
Carried forward................................		$148 720 878

* Secy., Motor Vehicle Conference Committee, New York City.

† "Facts and Figures of the Automobile Industry", 1921 Edition, p. 48, published by the National Automobile Chamber of Commerce.

Brought forward		$148 720 878
State:		
1.—Registration and license fees	$102 000 000	
2.—Personal property taxes	50 000 000	
3.—Miscellaneous taxes (motor fuel taxes, motor transportation franchise taxes, mileage taxes, business taxes on manufacturers and dealers)	5 000 000	
		157 000 000
Municipal:		
1.—Registration and license fees	$1 000 000	
2.—Miscellaneous taxes	10 000 000	
		11 000 000
Grand total		$316 720 878

Since $168 000 000 of the grand total of $316 720 000 for 1920 was yielded by State and municipal taxes on 9 211 295 motor vehicles, and since this registration was an increase of 22% over the number registered in 1919, it is fair and conservative to assume, despite the current period of economic depression, that by the close of 1922, the two-year interval will develop at least an increase of 25% in the number of registrations recorded at the close of 1920. On this assumption, and on the same scale of taxes and fees that obtained in 1920, one can logically expect State and municipal taxes, in 1922, to yield 25% more money than in 1920, or approximately $210 000 000.

This, however, does not tell the whole story. During 1921 forty-two State legislatures met in regular session and five in special session, and with few exceptions the law-makers of these States increased the annual registration fees to be effective for motor vehicles during 1922, from 10%, 15% and 20% to as much as 400% and more in certain cases. Moreover, the tax rate on the motor vehicle as personal property has everywhere had an upward tendency, and to add to the impositions, eleven new States, making the total fifteen at present, are now taxing gasoline and other fuels used by motor vehicles.

During 1922, only eleven State Legislatures will hold regular sessions. Nine of these have already convened and scarcely had their deliberations begun, before bills, providing for gasoline taxes, increased registration fees, wheel taxes, etc., for the motor vehicle, put in their appearance.

In view of the figures given, and in view of the circumstances mentioned, is it too much to believe that during 1922, the motor vehicle will pay $250 000 000 into State and municipal treasuries? On the other hand, lower production of motor vehicles and accessories in 1922 than in 1920 will decrease the Federal excise taxes to about $100 000 000, making the grand total for all impositions on the motor vehicle $350 000 000 for the year.

With the exception of the personal property taxes, these levies on the motor vehicle are special or exclusive. They are not imposed on farm machinery, for instance, in spite of the fact that the 3 000 000 to 4 000 000 motor vehicles owned and used by farmers are hardly less useful and necessary to them than their plows, harrows, cultivators, and other tools. Why should agricultural implements and countless other products of the factory be exempt from excise

taxes, and the motor vehicle and its parts be called on to pay $1 500 000 of such taxes annually?

As for the personal property tax, here, too, although this levy is presumably general in application to all kinds of personal property, it usually falls with special and even discriminatory force on the motor vehicle. As evidence of this, a typical case in a near-by State can be cited where the personal property tax levied on an automobile exceeded the same tax on all the household goods including pianos, talking machines, rugs, etc., in the house of the owner of that automobile. In effect, therefore, if not in intent, the personal property tax levied on motor vehicles in thirty-seven States is proving a special imposition.

Indeed, when all the taxes imposed on motor vehicles by the Federal Government, the States, counties, and municipalities are closely examined, it can be seen that either in theory or practical application they bear with exclusive or special force on the motor vehicle.

This situation makes it apparent that even if it were to be admitted that highways are of special benefit to motor vehicles, these same motor vehicles will, during 1922, contribute in the form of special fees, thirty-five cents for every dollar that will go for public highway financing in 1922. Will this highway financing, however, benefit the motor vehicle specially or exclusively? The answer to this question, coupled with a quantitative and qualitative estimate of this special and exclusive benefit, can alone enable a determination of what part of the highway financing the motor vehicle should pay.

Who Benefits from the Highway?—A man living on the outskirts of a city is suddenly stricken with a serious illness. His doctor speeds to his side in an automobile, diagnoses his malady, prescribes an operation, rushes him to a hospital in an automobile ambulance, and by virtue of the time saved by motor vehicles operated over good highways, saves the man's life. Who used the highways? Who benefited from them? Obviously, both the sick man and the doctor, but where can the line be drawn? Should the sick man who owned no automobile but who was made well by a combination of motor vehicles and good highways, pay nothing or everything or 25% toward highway financing? What should the hospital and the doctor who owned and operated the motor vehicles, and whose efficiency were increased thereby, pay? Clearly, the mere putting of these questions demonstrates the futility of seeking an accurate answer by this method of assigning intangible and unmeasurable benefits.

Let us try another example: By virtue of motor vehicles and good highways many farmers, factories, jobbers, and retailers are now avoiding heavy handling, transportation, and marketing charges, thereby greatly increasing their gains, but, at the same time, lowering costs to the ultimate consumers, many of whom do not own automobiles. Who are the beneficiaries in this case? What are the kind and degree of the benefits? How should the costs of the highways which made the benefits possible be apportioned?

Illustrations of this kind could be cited indefinitely, all tending to show that the advantages of good highways accrue alike to the public as a whole and that part of the public which owns and operates motor vehicles. In this case, again, however, such illustrations prove how impossible it is to take bene-

fits, which are shared by the general public and the motor vehicle owner alike, as the measuring stick for the relative portions of highway financing that both should carry; and do not forget that the motor-vehicle owner is also a part of the general public, as is the non-owner, and does not escape any of the general public's burdens by virtue of his ownership of a motor vehicle.

There is a beneficiary who derives untold advantage from the motor vehicle and good highways, yet in all discussions of the subject and virtually in all legislation he is entirely lost sight of. He is the owner of real estate along the improved highways. When the owner of 50 acres of land, on an unimproved dirt road, will accept $100 per acre for that land prior to the conversion of the dirt road into an improved thoroughfare, usable at all seasons of the year, and following the improvement refuses an offer of $200 per acre, it is obvious that he has received a direct, immediate, and tangible benefit of more than $5 000 by the mere completion of the public improvement. Furthermore, he benefits indirectly by having his land placed in economical contact with all other territory that the highway and its connections serve, and this circumstance, in turn, as the flow of traffic increases, advances real estate values thus, ever accruing to his direct benefits.

The Fundamentals of Highway Financing.—Leaving the general public and the owners of property abutting on improved highways to fight out, what, if any, shall be their relative shares in highway financing, let us seek to determine what, in sound economics and justice, the motor vehicle should pay toward the vast annual outlays that the Federal Government, the States, counties, and municipalities are making for good roads.

An intelligent decision regarding this proposition can only be reached by a realization of the vital elements of highway financing. Careful analysis shows that these fundamentally consist of capital investments and current expenditures. Under the former should be included the cost of surveys for highways; acquirement and clearing of rights of way; grading; drainage; laying of foundations; original construction of highway pavement; widening of highways or pavements; and reconstruction after a highway can no longer be economically maintained. Furthermore, where the capital investment has been made through the deferred payment or bond issue method rather than by the pay-as-you-go or cash method, the carrying and amortization costs for such bonds should be charged to the capital investment account. On the other hand, current expenditures should embrace the maintenance of highways, regulation of their use, and administration of the highway departments.

After giving serious study to these matters, the Motor Vehicle Conference Committee, composed of representatives of the American Automobile Association, Motor and Accessory Manufacturers' Association, National Automobile Chamber of Commerce, National Automobile Dealers Association, Rubber Association of America, and the Trailer Manufacturers Association of America, has definitely taken the stand, that the aggregate amount of excise taxes and all those other forms of special impositions levied on the motor vehicle, should in no case ever exceed the amount of money needed to meet these current expenses. Moreover, the Committee is insistent that maintenance charges should be levied on the motor vehicle only for highways

properly located to meet the economic needs of the community and built of such materials and in such a manner that they will efficiently and economically meet those needs. It is contended that the general public—which includes motor-vehicle owners as well as non-owners—and abutting property owners who are also made up of motor-vehicle owners and non-owners, should meet the cost of the capital investments necessary for improved highways.

When it is realized that the American public, prior to the era of motor vehicle transportation, spent scores of millions of dollars for the improvement of highways for animal-drawn transportation and never charged that transportation a penny of special taxes, either for capital outlays or current expenses, it can be seen that the position of the motor vehicle as reflected by the Conference Committee is fair, if not generous.

More than that, if the proposition must be accepted that good highways confer special benefits on the motor vehicle, then special motor-vehicle impositions for the current expenses necessary for maintenance, regulation, and departmental administration, is perhaps the most accurate measure that can be found of those special benefits. Motor-vehicle owners as a substantial and heavy paying part of the great army of general taxpayers, together with non-owners, contribute toward the capital outlays necessary to establish improved highways that redound to the general good of every one. Then come the motor-vehicle owners to use these highways. Disregarding the fact that this use, more often than not, is advantageous to others beside these owners, it must be admitted that they subject the highways to wear and tear. The special fees which they pay, offset this wear and tear. Here, then, is a justification for exacting from the motor vehicle the current expense fundamental of highway financing. After this is granted, however, why should law-makers, with increasing insistence, call on the motor vehicle for greater taxes and extra taxes to meet capital outlays?

To be sure some may disagree with the particular phases of highway financing which have been listed in this discussion under the headings of capital outlays and current expenses; it is almost certain that there will be the greatest diversity of opinion as to what the expressions, highway maintenance, highway regulation, and highway administration should include. Even so, the speaker is confident that once those who are working on the problem shall have agreed on what shall constitute capital outlays and current expenses, they will subscribe to the position that special tax impositions on the motor vehicle should never, in Federal, State, county, or municipal highway financing, be greater than is necessary to meet current expenses.

THE MOTOR TRUCK AS AN ASSET TO RAILROAD OPERATION

By R. S. Parsons,* M. Am. Soc. C. E.

During 1922, more improved highways will be constructed in the United States than ever before in a similar time. Federal, State, county, and city appropriations, aggregating more than $1 000 000 000 are being set aside for this purpose. It is the passenger vehicle that makes road construction a question of popular interest and this enormous undertaking possible, but it is the motor truck that sets the standard of road construction and makes the expenditure of economic interest. Railroads are concerned in this work, as they are taxpayers to the extent of over $200 000 000 yearly, a large part of which goes into the highway budget.

The motor truck has demonstrated its ability, as a mechanical device, to move freight promptly and efficiently. Consequently, railroad managements must accept the inevitable and meet the motor truck as an ally rather than as an enemy. Inasmuch as a benign public has seen fit to provide the right of way, roadbed, and track for this means of transportation, it is the duty of the far-seeing railroad manager to welcome it as an aid and not condemn it as a competitor.

Some of the conditions under which motor-truck operation can be substituted for present-day railroad operation are:

1.—Short branch-line operation.

2.—Trap car service.

3.—Suburban distribution.

4.—Utilization of outlying yards in lieu of yards in congested districts.

5.—Terminal distribution.

Short Branch-Line Operation.—Branch lines of light traffic are unprofitable. Motor trucks, on improved roads, can be substituted for both passenger and freight service and the railroad lines can be abandoned. If improved roads do not exist, the right of way and roadbed of the branch line can be turned over to the proper authorities for the construction of a highway. An instance of the use of this arrangement may be found in the utilization of a part of the abandoned Delaware, Lackawanna and Western roadbed by the Pennsylvania Highway Commission for the State Road between Binghamton, N. Y., and Scranton, Pa.

Trap Car Service.—In industrial centers, many industries produce freight for diversified points. This freight must be assembled at some central station and consolidated for various destinations. The movement of the cars of freight for miscellaneous points, between the industry and transfer platform, is known as trap car service. It is usually performed through congested yards, and in order to render proper service must be performed on specified schedule. This renders the service expensive, and the cars used in this manner take up unnecessary room in the yards to the detriment of through service. This trap car service can be performed by motor trucks much more cheaply than

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by the use of cars. The result is an expedited movement with real economy, a saving of equipment, and relief of congested yards to the advantage of carload outbound freight and inbound raw materials.

Suburban Distribution.—Every large city becomes surrounded by a suburban area of more or less intensive development. The use of the expensive terminals of the railroads for local distribution throughout these areas results in an economic loss and requires the development of much larger terminals than would otherwise be necessary if such local distribution were eliminated. Freight for local distribution cannot be refused, however, as such action would affect the solicitation of profitable long-haul business. Terminal costs more than absorb the entire freight rate on local distribution of this character. Motor-truck distribution through suburban areas, within a radius of from 30 to 50 miles (depending on the condition of the roads), is more satisfactory and economical than similar distribution through the medium of city freight-houses and way freights. This method of distribution in the New York suburban area should be cultivated by all railroads.

Utilization of Outlying Yards in Lieu of Yards in Congested Districts.—In rare instances, railroad managements have been far-sighted enough to anticipate the growth of cities and to prepare adequate yard room to accommodate the increase in business. Where this has not been done, it results in later years in the necessity of purchasing areas at great additional cost and under disadvantageous circumstances. The growth of a city compels much additional expense on account of the elimination of grade crossings and diversion of highways; also municipal ordinances against smoke, noise, and the blocking of crossings, make the operation of internal yards extremely expensive. The elimination of such yards; the selling of the valuable property released thereby; the use of funds so acquired in the construction of more properly designed yards outside the city limits; together with the institution of motor-truck service to interior stations, would undoubtedly prove economical in many instances.

Authorities agree that the proper measure of cost of operating motor trucks is the cost per day rather than the cost per mile. As the daily mileage increases, the cost per mile will decrease. There are so many items of this expense that are not absolutely dependent on the mileage made, that an additional mile—or even two—between outlying yards and city freight houses will not increase the cost of trucking service proportionately.

Terminal Distribution.—The growing opposition to grade crossings and the expense of eliminating them; the increase in municipal and State taxes; and the enormous cost of real estate, render the building of industrial tracks in the heart of great business centers impossible. Here, the motor truck becomes a necessary aid in combating undue terminal charges.

In St. Louis, Mo., with its population of nearly 800 000 people, practically all the railroads terminate their freight activities at East St. Louis, and all carload and less than carload freight, where there is no direct connection with an individual industry, is contracted by a trucking corporation, which provides inland stations and delivers carload freight and truck freight from East St. Louis across the bridge to St. Louis.

The tractor and trailer system which is used at this point, delivers carload and less than carload freight between the railroad and the consignee on inbound and outbound freight. This system takes up the lost motion on the motor unit, three trailers being provided for each tractor. The haul at this point averages about 2 miles, and the tractor with its three trailers can handle about 45 tons of freight per day, at a cost of about 70 cents per ton.

As a demonstration of the economy of this method, it might be cited that only a short time ago the Pennsylvania Railroad, with an all-rail line connection in St. Louis, diverted its freight to this tractor-trailer method of distribution.

In Cincinnati, Ohio, the demountable body, or container, is used, the operation being confined to the transferring of less than carload freight from one railroad to another. The demountable body has the same advantage as the tractor-trailer in allowing the motor to continue in operation while the loading and unloading takes place. Hoists, at loading and unloading points, quickly remove the container from the truck chassis. The average haul is about 1½ miles and the cost is about 51 cents per ton.

In New York City, a radical departure is being made at the present time in terminal distribution of inbound freight and the collecting of outbound freight. Under a contract with the United States Trucking Corporation, the Erie Railroad delivers its cars to the Trucking Company in its yards on the New Jersey shore. The freight is loaded on trucks and ferried to New York City, utilizing the ferries, in so far as possible, at times other than during peak loading. A common rate is paid on all freight trucked to an imaginary point in West Street. From this imaginary point, freight is distributed: First, to piers for steamship loading; second, to inland freight stations; and third, for store door delivery. Different additional rates are allowed for these three methods of distribution. In the case of steamship delivery, freight is unloaded on docks the same as any city freight that may be so handled.

In the second instance, inland freighthouses have been developed by utilizing ground floors of warehouses, owned by The Independent Warehouse Company, at Beach, Greenwich, Leroy, and Montgomery Streets. Through an arrangement with the Warehouse Company, freight may be floored for immediate delivery to the consignee or may be elevated into warehouses at the consignee's request for subsequent delivery. These inland stations are in every respect railroad stations.

The third method of delivery is worked out between the Trucking Company and the consignee, the latter preferring, in many instances, to receive his freight from the Trucking Company rather than have it go through the inland stations. This reduces the cost of handling freight both to the Trucking Company and consignee and expedites delivery. True economy, however, cannot be reached in this work until specially constructed trucks of either the "container" or "trailer" type have been placed in the service.

With the completion of the Vehicular Tunnel and the elimination of the ferry service with its resultant delays, this method of delivering freight to New York City will meet with increasing favor. It is a well-advertised fact that it costs as much to move a carload of freight from the railroad yards in

New Jersey and deliver it in New York, as it does to move the same car of freight from the same yards to Buffalo, N. Y., or Pittsburgh, Pa. Any method, therefore, which reduces this large expense (which is principally in the maintenance, operation, and repair of lighters, tugs, and docks), will be welcomed.

There has been a noticeable shortage of steamship pier space on the North River for some years, due to the fact that 30% of all the piers are being used by New Jersey railroads for the purpose of delivering freight to New York City. Through the trucking method of delivery a large proportion of these piers will be released and can again be used for steamship purposes. It is a pity that this proposition had not been worked out before the steamship piers on Staten Island were built, as the burdens which will be imposed on the railroads for a long time to come through lightering to this distant point, will be a marked reflection against the economical operation of the port.

The New York-New Jersey Port and Harbor Development Commission contemplates the construction of vast assembling yards on the New Jersey meadows, where cars from all railroads will be assembled; extensive transfer stations, where freight will be taken from cars and loaded in containers for transfer to tunnels; an extensive tunnel system, where small cars automatically and electrically operated will transport this freight to points underground in New York City for further handling and distribution; and warehouses and freight stations in New York City to facilitate this distribution.

In this construction more than $200 000 000 must be spent and when it is in operation, any freight so handled, after it has reached the city, must ultimately depend on the motor truck to reach its destination, the only exception being where the receiver of freight is fortunate enough to be located adjacent to one of the terminal stations.

With the Vehicular Tunnel from Canal Street, New York City to Jersey City in operation, freight may be loaded directly from cars in New Jersey to motor trucks and without further re-handling be distributed directly where required by the receiver.

Except for the North River, the Port Development Plan would not meet with a moment's consideration. Let us, therefore, undertake to eliminate the North River by the construction of a series of tunnels, at a cost much less than the Port Plan.

First.—Build a tunnel from Lower New York to a point adjacent to the existing freight yards of the Jersey Central, Lehigh Valley, and Pennsylvania Railroads.

Second.—The new Vehicular Tunnel, now under construction, between Canal Street and a point adjacent to the yards of the Erie and Lackawanna Railroads, will take care of freight unloaded at these points.

Third.—Build a tunnel from a point near 50th Street to a point adjacent to the West Shore Tunnel, for the handling of the business of the West Shore.

Fourth.—Build a tunnel from 125th Street to a point adjacent to the freight yards in the vicinity of Fort Lee Ferry.

Fifth.—Build a belt line along the Hackensack River to the New Jersey Meadows, connecting with all the railroads mentioned. At the present time.

tracks are available for about half this distance. Over this belt line, freight consigned to New York City could be moved to the most adaptable yard, unloaded at existing team tracks, and trucked directly to point of destination, eliminating any north and south trucking in New York City.

This plan, as outlined, would cost much less than the plan under consideration and would give relief to the entire city instead of to a small part of it, and, in addition, would expedite the movement of pleasure vehicles in and out of the city. Trucking of this nature would not add to the congestion of New York City streets as the same freight is now trucked between warehouses, ferries, and the pier railroad stations. The advantage to the railroads lies in the elimination of the tremendous cost of lighterage, the two additional handlings now necessary in loading and unloading the lighterage, and the incidental saving of loss and damage account, a large proportion of which accrues at transfer points. The latter item for all railroads during 1921 amounted to more than $100 000 000.

MOTOR VEHICLE CONTROL

By G. Wythe Munford,* Esq.

Motor vehicle control, as it has been evolved in Maryland, to keep pace with the development and steadily increasing use of the automobile, is now grounded on four essential requirements. Although continued expansion of motor vehicle traffic may require enlargement of official regulatory power, experience leads to the belief that these four requirements are basic and essentially permanent.

Proper and effective regulation and control requires that close check at all times be kept on the individual car once it has been identified and recorded. This record of the car as it goes into the "used car" class must be permanent. Ready identification and a maximum of ease in tracing to its owner any car seen on the highways must be provided. Before being turned loose on the highways the driver, for the protection of himself and to safeguard others, must undergo some mental test and give practical demonstration of his fitness and ability. Once permitted to operate, the driver at all times must be easy of identification and location. These requirements constitute Maryland's four basic principles of motor vehicle control. These ends are accomplished in the following manner.

First, there is a Title Law; second, the ordinary system of yearly registration, and issuance of a numbered metal tag is used; third, each chauffeur or operator must submit to mental examination and give practical demonstration of his or her ability to operate a car, and, fourth, every driver is assigned a permit to drive and given a number.

The Title Law, although it is mentioned first, constitutes the latest addition to the system. In addition to its other advantages, it has done much to check automobile theft. It has made the "auto Jack's" vocation more hazardous and correspondingly less profitable. Under it, no Maryland automobile, motor cycle, or side car can be sold or bought in the State without there first having been an exchange and recording of a title deed between the vendor and vendee. The transaction of sale is conducted in manner somewhat similar and is, indeed, supervised more closely and protected more completely than an ordinary sale of real estate. Not only must the deed or title of ownership contain a minute description of the external characteristics of the car; it must also identify the engine or motor by its original factory number.

Such a statute, of course, would be useless if it did not contain heavy penalties. Provision for a fine of as much as $1 000, or a jail sentence up to 7 years, or both fine and imprisonment for the mere having possession of a motor vehicle from which "the trade mark, distinguishing or identifying number, serial number, or marks has been changed or is changed, covered, removed, defaced, destroyed, obliterated or altered" is indication of the severity of the penalties.

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Forgery in application, misstatement in application, or any alteration of a title of ownership once issued, carries penalties of from $1 000 to $5 000 fine, or jail sentence up to 10 years, or both fine and imprisonment. Equally deterrent penalties are provided for having in one's possession a car or cycle for which title has not been issued.

All titles of ownership are issued and a record of them kept in the office of the Commissioner of Motor Vehicles. The same requirement governs all transfers or assignments of title. Through this system every motor vehicle in the State can be traced back to its original owner. Its present owner's name and address is at all times a matter of public record.

If a car is stolen and its motor number is changed or obliterated before it is recovered, or, in cases of cars which had been sold prior to the passage of the Title Law, with bad numbers, the Commissioner assigns that engine a new number. This substituted numeral, with the identifying initials "A. C."—for Automobile Commissioner—added is indented on the motor. By it, the car is known and identified in all subsequent sales.

The title records give the authorities at all times a complete and a permanent description and record of present ownership and approximate location of every motor vehicle in the State. This record is independent of the system of yearly registration of all cars and assignment to each of two numbered metal tags which must be displayed at all times—one in front and one to the rear. When these tags are issued yearly, they are assigned to a specified car. They cannot be used on any other. They will not be issued except in the name of the persons whom the title records show to be the owner of that particular car. These registration numbers are issued for the calendar year, or any quarterly proportionate part thereof.

The system of yearly registration and identification tag issuance goes further, however, than the simple assignment and issuance of numbered display tags for road identification. A card describing the name or make, the color and type of body, the color and type of wheels, and containing also the factory-given engine number, as well as the tag numerals assigned it for that year, must be carried at all times with the car. This card is issued by the Commissioner. On it is also stamped the ownership or title reference in the files. This system, for violation of which severe penalties are provided, gives at all times speedy identification and tracing of a car while it is on the highways.

Of course, the inanimate car or motor cycle is thus at all times so marked as to be easy of identification and location after an accident or traffic violation. It is, however, after all, the driver who is wanted in such cases.

The Maryland law endeavors, first, to keep all persons from behind the steering wheel and away from the gear control of a motor vehicle until he or she has demonstrated ability to operate a car, with the minimum of danger to others, and has a working knowledge of traffic regulations and the rules of the road. This is accomplished through the issuance first of a beginner's license or instruction permit. Under this permit, the new driver is forbidden to operate a car unless a fully licensed and experienced operator or chauffeur is present. This permit is good for only thirty days, but may be renewed, and often is extended if the learner has not become proficient in that time.

After the period of instruction and actual experience in operating a car, always under the eye of an experienced driver, the applicant reports for an examination. Specific dates are advertised in the counties for these tests, which take place usually at the county seat. Demonstrators or examiners are on duty for this purpose at all times in the Headquarters Office in Baltimore. First, there is an oral test to determine what the applicant has learned of the working parts of his vehicle, and what his conception of his own and the other person's rights are on the highways. Passing this successfully, the applicant gives a demonstration. With a representative of the Commissioner on the seat with him, he is compelled to start and stop the car, take it through fairly heavy traffic, back it, stop after stalling on a hill, etc. If the applicant cannot meet the standard in these tests there must be a further period of operation on an instruction permit, another test, and another demonstration.

The fact that many applicants are often sent back for instruction two and three times indicates the importance of this examination and the requirement for a standard of qualification. Some have never been able to qualify. The weight that is given to proper preparation and qualification of drivers is indicated through the fact that, in cases of sub-normal mentality or a suspicion of such a condition, the Commissioner can require the applicant to go before a board of physicians for examination. Sixteen years is the minimum age limit for drivers.

Having set a standard that "would-be" drivers of motor vehicles must meet before being turned loose on the highways, Maryland lists and indexes every chauffeur and operator in the State, and issues him a numbered card on which is his name, address and a description of his physical characteristics. This card must always be carried and must be shown on demand, following any violation or accident. Demand that the operator's card be shown under such circumstances can be made by any one, not necessarily an officer of the law, and refusal to do so entails severe penalties.

As a further protection, these permits are subject to suspension for various periods or to revocation by the Commissioner. All such suspensions and revocations are handled by the Commissioner. The magistrates trying cases of violation are limited to imposition of fines or jail sentences. A magistrate's acquittal on a charge, however, does not estop the Commissioner from independent action. He is the final judge of the right of a driver to retain his permit. He conducts independent investigation of violations and often revokes or suspends the license of an operator who may have been exonerated by a trial magistrate.

As a check on the record of drivers, all magistrates are required to make detailed reports to the Commissioner on all cases tried by them. From these reports with the disposition of the case a complete file of difficulties or violations of every driver is centrally assembled. In this way, each driver's record of conduct, and a determination of second or subsequent offenses, is made constantly available.

Suspension or revocation of a driver's permit denies him or her the right to operate within the State. Violation of this section is penalized by fine from

$100 to $1 000, or a jail term of from 30 days to a year, or both fine and imprisonment.

In each of these stages of regulation, except in the case of the examination and demonstration by the driver, a fee is collected. The drivers are grouped into three classes: Chauffeur, including those who drive for hire; operator, who drives for pleasure or operates his own car; and motor-cycle operator. These pay, respectively, $3, $2 and $1. Issuance of each title or transfer of title entails a cost of $1, plus the notarial fee. There are 331 565 drivers of all classes paying $787 695 annually, the increase in 1921 being more than 25 per cent.

Charges for registration and issuance of marker tags are based on the rated horse-power for pneumatic tire vehicles and on a straight-tonnage basis for solid tired cars. Any vehicle with two non-pneumatic tires is rated as solid-tired. The pneumatic-tire rate is 60 cents per h. p. for pleasure cars. Hiring cars or taxicabs pay twice this rate.

The system of registration regulation and basis of fees has one exception. This exception constitutes the only point in which there is a division of jurisdiction between the Motor Vehicle Commissioner and any other governmental department of the State. It has to do with franchise rights and the regulation and costs for operating passenger and freight bus lines over established routes on arranged schedules of service. In this case the Motor Vehicle Commissioner and the Public Service Commission, controlling all public utilities in the State, share administrative functions. The speaker will touch on this phase of motor control, as Maryland now handles it, more fully later.

From all the fees collected, with the exception of those derived from the Titling Department, is created, after the administrative expenses of the Motor Vehicle Commissioner's office are met, a fund devoted to the maintenance of the State's highways. None of it goes to construction; it is merely applied to putting back into the road's surface what the automobile takes out of it in wear and tear.

Some idea of the growth and the increased requirements for the regulation of motor vehicles in Maryland may be gleaned, however, from a comparison of the gross income from motor vehicle registration, when Maryland first attacked the problem in 1911. Determining to lay down a system of modern hard-surfaced highways, on which $26 000 000 has since been spent for construction, the State turned to automobile license fees to take care of these roads after they were built. In that year, or in the succeeding fiscal year, the gross receipts were $56 204. The last annual report just sent to the Governor shows gross receipts in 1920-21 amounting to $2 451 166.08, an increase of more than 400% in 10 years. The administrative problems are multiplying more rapidly than the income. This is best shown in the fact that in the calendar year 1921 18 000 more pleasure cars alone were registered than in the preceding twelve months.

In view of the discussion by the Society of the question of Highway Transportation, a word or two of Maryland's attitude to this problem, as it affects both motor vehicle control and highway construction and upkeep, may

be interesting. Although recognizing the inevitability of continued expansion in the field of truck transportation, Maryland is now discouraging heavy unit tonnage transported on solid-tired vehicles. With mounting tonnage on solid tires the fees are being sharply boosted. Beginning with the 1-ton truck, the State collects $20 per ton, up to a 3-ton vehicle. Then the rate goes up; $100 for 4-ton trucks, $150 for 5-ton, $300 for 6-ton, and $500 for 7-ton vehicles. However, although the State is still licensing 6-ton and 7-ton trucks which were owned and registered in Maryland prior to 1918, it now has a 5-ton maximum for all other cars of this type, and limits the gross weight to 20 000 lb. Even with these restrictions, 11 597 solid-tire trucks were licensed in 1921, the fees totaling $371 000.

In the realm of motor vehicle control of all trucks, the State has special provisions. To enforce the gross weight law, roadside scales of the ordinary type for vehicle weighing have been installed at strategic points on through lines of traffic. To these scale boxes, the motor-cycle police have keys, and any truck under suspicion of being over weight must submit to weight on demand. Fines of as much as $100 for each over-weight truck are provided.

The State also has a maximum width law for trucks which limits the width to 90 in. The speed limit for solid tired trucks is decreased as the tonnage increases. The carrying by all trucks of a mirror adjusted so as to give the driver a view of the road to his rear, is also compulsory.

The truck-regulation provisions just cited cover both the free-lance truck, which will, as they so often advertise, haul anything, anywhere, anytime, and the regularly scheduled freight hauling motor.

In the latter type of vehicle, however, as well as in the case of the passenger bus covering an agreed and fixed route on a regular schedule as a common carrier, the administrative jurisdiction is shared with the Public Service Commission.

The Service Commission controls the franchise, compels the observance of schedule, fixes the freight and passenger tariffs, and hears and adjudges controversial questions arising between the operating company and its patrons.

The Commissioner of Motor Vehicles assesses and collects the license fees for registration, issues and enforces observance of the provisions of chauffeurs' permits, and compels observance of the traffic regulations. He also issues the registration identification tags, which are distinctive for this type of vehicle, and administers the Titling Law.

The passenger bus in this service is licensed on the basis of one-twentieth of 1 cent per passenger mile for the entire scheduled route and for the full capacity of the vehicle, for buses weighing less than 3 000 lb. Buses, weighing between 3 000 and 7 000 lb. pay one-fifteenth of 1 cent per passenger mile, and those weighing more than 7 000 lb. are assessed one-sixth of 1 cent per passenger mile.

With freight-carrying buses, the fee is collected on a ton-mile basis. These fees are: one-fifth of 1 cent for a 3-ton truck or less; two-fifths of 1 cent between a 3-ton and a 6-ton, and three-fifths of 1 cent for all trucks of over 6-ton gross capacity.

The joint regulation of such traffic is not limited to rural service. It applies also to the Charles Street Bus Line of the United Railways and Electric Company, in Baltimore, and to all jitney lines operating in that city and the smaller towns of the State.

From 260 buses of various types so licensed the fees for 1921 totaled \$44 734.18. That this business is also growing is indicated by the fact that this sum was exceeded by nearly \$1 400 in the first license rush at the beginning of January. With the opening of the many rural resorts, to which such lines are in increasing numbers devoting their attention, the spring and summer will see an even further increase.

This source of expected further increase does not indicate any limitation of chartered bus and truck lines to summer-time operation for rural resort service. In Maryland, as elsewhere, the passenger, baggage, express, and freight motor traffic is well out of its swaddling clothes, although as a rural highway transportation development it is still treated as somewhat of an infant industry.

Because of this, and because it is looked on as an important and effective instrument for rural community development, the State is protecting all properly financed and efficiently managed lines; it protects their lines and routes and discourages unstable and irresponsible competition.

In large agricultural areas, devoid of either rail or water transportation, motor-bus lines are now furnishing for the first time in the history of these localities satisfactory and convenient connections with the outside world.

As distinguished from scheduled and routed bus lines, the 4 161 taxicabs and hiring cars not operating over any fixed routes paid in 1921 in fees to the State \$110 663.65. Pleasure cars, of which there were licensed 120 231, added \$1 468 969.04 to the State's income. Income from State dealers, dealers in transit, motor cycles and other sources, might also be discussed.

Over and above principles and requirements in the theory of motor vehicle control, because these are useless and practically unenforcible without them, is the body of uniformed, trained, and motor-cycle mounted police. The psychological effect of such a force in restraining the potential "speed king" and reckless driver can hardly be estimated.

In addition to the safety they bring to rural highways, their contribution to motor vehicle control results in the collection of fines sufficient to pay their daily running expenses.

DISCUSSION ON HIGHWAY TRANSPORTATION

By W. K. Hatt, M. Am. Soc. C. E.

W. K. Hatt,* M. Am. Soc. C. E. (by letter).†—The main problem of highway transportation is in the field of economics. Since a limited amount of the National wealth is available for transportation, what is spent on highway transportation beyond the economic necessity will diminish the amounts that should be applied to other agencies of transportation, such as railways and electric lines. The central need, therefore, is the organization of the transportation agencies of the United States so that each may preserve its proper economic relation to the others. The data on which the solution of this problem may be predicated are largely wanting. Such data result from traffic surveys and analysis of data of costs that arise from the road and from the vehicle. It is in this economic field that the greatest opportunity lies for useful and fruitful research. Scientific correlation of transportation agencies should replace conflict.

It is well known that in industrial regions like the State of Connecticut, the railroads have been largely relieved of their less than carload business which is now carried by motor trucks over the highways. It is reported that between Bakersfield and Los Angeles, Calif., 63% of the freight finds its way over the highway, at a cost of 18 cents per ton-mile as against 5 cents per ton-mile on the railway. Of course, speed of delivery and absence of terminal charges are the deciding factors in such traffic. In the vicinity of Seattle, Wash., it is said that the development of motor transportation companies has diminished the need of the farmer for his own truck. His products are placed on a platform in front of his farm and are delivered by a transportation company to the city, and the commodity that he desires is returned to him. The economic radius of such highway traffic is variously fixed at from 50 to 100 miles, depending on conditions, but the real economic radius will be affected by distribution to the truck, of costs that are not in the present balance sheet. That this truck transportation is here to stay cannot be doubted for a moment.

From 1910 to 1921, the motor vehicles increased in number from 501 000 to 9 750 000, that is, 1 800%, and the trucks increased from 2.8% to 10.3% of total vehicles. At present, there are nearly 8 500 000 automobiles and 1 333 000 trucks.

Preliminary figures indicate the investment in highway transport to be $20 000 000 000 outside of cities, including vehicles, garages, and roads, an investment equal to that in rail transportation. The motor vehicles represent an investment of $10 000 000 000. Nearly one-third of the vehicles are owned by farmers. There are 20 000 motor buses in operation; 12 000 schools are using motor buses for transporting children. Motor express lines now in operation number 1 500, and 6 000 000 head of live stock were transported by motor truck in 1921. In Connecticut, a truck load of silk products valued at

* Director, Advisory Board on Highway Research, National Research Council, Washington, D. C.

† Received by the Secretary, January 20th, 1922.

$100 000 passed over the roads. In Iowa, there is 1 car to every 4.5 persons; on the average, there is 1 car to every 10 persons in the United States.

The total operating expenses of motor-vehicle traffic—passenger and freight—in the whole United States are so large that the fixed charges from capital costs and the additional maintenance costs arising from the road appear to be of less importance in relation to the total cost of transportation than would be supposed. Using data which represent reasonable estimates rather than exact statistics, one finds the following:

During 1921, the money spent on highways in the United States for State, county, and other roads outside of cities, was: Construction, $420 000 000; maintenance, $180 000 000; total $600 000 000.

There were 9 750 000 vehicle licenses, that is, 8 404 000 for automobiles and 1 346 000 for trucks. If the cost of the road is divided by the number of vehicle licenses, it appears that the total road expenditures for a licensed car are, as follows: Spent on maintenance per license, $18.60; total expenditures per car license, $61.50. Fixed charges arising from previous construction are not included.

Turning to the other side, one may ask what revenue was received from the licensed vehicles. During 1921, approximately $118 000 000 were paid for vehicle licenses in the United States, and approximately $120 000 000 of excise taxes, the latter of which did not go directly back to the roads, or a total of $238 000 000.

In a similar manner, one may divide the revenues received by the number of licenses, and find that the revenue per car for license fees was approximately $12 per year, and that adding the excise tax the total revenue from the car is approximately $19.

In other words, the car licenses paid about two-thirds of the cost of maintenance of roads. Of course, this showing is likely to be misleading because some money is spent on roads over which there is little automobile travel, and then, again, not all the money paid for license fees is returned to the roads. In addition, license fees are received from vehicles that travel almost entirely on city streets. One must also remember that large sums of money are spent by counties and townships in excess of revenues received by the State for license fees.

It is difficult to examine the calculation for individual States on account of diversity of practice in financing. However, proceeding as indicated, for the States of Iowa, Michigan, New Jersey, New York, and Pennsylvania, it is found that in 1920 the license fee per car was from $13.10 to $17.00, or an average of $14.53, and that the road expenditure, including construction costs for 1920, and maintenance costs, runs from $29.15 to $69.00, an average of $47.65.

Of course, the total highway expense for 1920 would include the fixed charges arising from the construction of preceding years. An effort is now being made by the U. S. Bureau of Public Roads to determine these costs for the entire United States.

As to the ability of the traffic to carry this burden, it may be said that the road licenses at present are probably not more than 2% of the total cost of

the transportation, that is, the truck owner or the automobile owner pays in road fees only about $2 out of every $100 of fixed charges and operating expenses. Therefore, if this $2 is increased to $4 for licenses or road fees, the total cost of transportation would be increased only by 2%, so that when the farming communities and other property holders ask that road construction be stopped in order that road taxes may be diminished, it would appear that the road programs might still proceed, if only those who use the roads are asked to pay for them in license fees, and gasoline tax or other method. This statement is made merely for the purpose of stressing the importance of the traffic and not as an argument for such a method of financing.

A sound theory of highway finance is needed to determine the distribution of the cost according to benefits. In this theory, the various elements of the road, such as right-of-way, grading, and structures, and the wearing surface, should be recognized.

Finally, it must be said that the maintenance work on the roads is not sufficient at present and should be increased.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

THE RELATION BETWEEN DEFLECTIONS AND STRESSES IN ARCH DAMS

Discussion*

By Albert B. Hill, M. Am. Soc. C. E.

Albert B. Hill,† M. Am. Soc. C. E. (by letter).‡—In this paper the author has raised some interesting questions which merit discussion.

If the deflections of the dam have been carefully measured and the character of the forces that produced the deflections, together with the elastic modulus of the material, are definitely known, the stresses resulting from the deflections should be determinable. There can be no serious question on that point.

In referring to "Stresses in the Vertical Cantilevers of Arch Dams", the author bases his method of determining those stresses on the "well known theory of stresses and corresponding deflections in cantilever beams". The usual formulas for cantilever beams are deduced from the theory of flexure, assuming the beams to be rigidly fixed at the base, with compression on one side of the neutral axis and tension on the other side. The writer questions if such formulas are strictly applicable to dams generally, which may not be rigidly fixed at the base.

The author assumed the dam to be "rigidly fixed at the base due either to its own weight or to special anchorage to the bed-rock". The value of the weight, as a fixing force, is limited to the condition of the dam as simply supported at the base. When the load commences to produce tension in the up-stream face of the dam near the base, the weight of the dam as a fixing force is exhausted. An adequate anchorage for rigidly fixing the base is required, if the formulas for rigidly fixed cantilevers are to apply. The absolute adequacy of such anchorage for rigidly fixing the base permanently, may be uncertain.

In his investigations of the Barren Jack Dam in Australia and the Salmon Creek Dam in Alaska, the author finds that the deflection curves, instead of being tangent to the normal at the base, make material angles with the normal at their intersection with the base. Such a condition indicates clearly, that

* Discussion on the paper by F. A. Noetzli, Assoc. M. Am. Soc. C. E., continued from January, 1922, *Proceedings*.

† Cons. Engr., New Haven, Conn.

‡ Received by the Secretary, January 6th, 1922.

whatever the intentions of the designers may have been, the dams are not rigidly fixed at the base, and renders questionable the application of formulas for rigidly fixed base. If the dams are simply supported at the base, the deflections would be greater than if they are considered as rigidly fixed at the base. This may help to account for some of the great differences between the measured deflections and the calculated deflections of the author.

The writer doubts the wisdom of using steel reinforcement for anchoring and for resisting tension in high concrete dams subject to heavy water pressure. It is imperative that important impounding reservoirs should be designed as permanent structures. The dangers to life and property and the loss that would be caused by a failure renders inadmissible the construction of any but permanent dams. The steel reinforcement to be most efficient should be reasonably near the up-stream face of the dam. The farther it is removed from the up-stream face, the more steel is required. The amount required is large in any case if the up-stream face of the dam is to be "rigidly fixed" at the base.

Concrete, if of good quality and under only light water pressure, may protect the steel fairly well. Concrete, however, is more or less porous and water, under heavy pressure, will be forced through a few inches or even a few feet of concrete. If the unit stresses are equal to those generally allowed in steel reinforcement, then, in accordance with the laws of elasticity, the steel will stretch somewhat. This will produce tension in the concrete, tending to open fine hair cracks and make it still more porous.

Water under high pressure is also likely to get to the steel through contraction joints and through construction joints where weak laitance may not have been entirely removed. Damp spots, where water has seeped through, are not infrequently noticed on the down-stream face near the bottom of dams of only moderate height, particularly soon after the dams are put in commission.

If water does get to the steel and corrosion takes place, the concrete is likely to be split and trouble will result where it may not be seen. Corrosion of the steel has already caused trouble in reinforced concrete stand-pipes built less than a score of years ago. The writer believes it is safer to omit the steel and use a little more concrete, and consider the dam as simply supported at the base, unless the steel is much more efficiently protected than in present practice.

A force which is helpful to the arched dam, and which seems to have been given little, if any, attention, is simple vertical beam action. Vertical slices of the dam may be considered as simple vertical beams, supported at the base in the rock and, to a limited extent, supported at the top by horizontal arch action. In considering arch action, the dam is assumed to be divided into horizontal slices free to slide on each other. On this assumption, the horizontal arch slices at the top, theoretically, are not stressed from water pressure, as they are above the water level. These top horizontal arches should be made to do useful work, which they actually do, by acting as limited supports to the top of the simple vertical beams.

The writer believes that the top of an arch dam should be of substantially the same thickness as the top of a corresponding gravity section dam. The rigidity of a simple beam varies as the cube of the depth. If an arch dam is, say, 12 ft. thick at the top and 60 ft. thick at the base, the thickness at the base being five times the thickness of the top, the rigidity near the base would be about one hundred and twenty-five times the rigidity near the top. The maximum water pressure is also at the bottom. Therefore, the simple vertical beam, with relatively small support at the top, is able by its rigid bottom portion, to transmit a material portion of the bottom water pressure, into the rock foundation.

The simple vertical beam action would tend to produce tension in the down-stream face of the dam, thereby neutralizing a portion of the compression in the down-stream face resulting from simple gravity action. It would also tend to produce compression in the up-stream face of the dam, helping to neutralize any tension in the up-stream face resulting from gravity action, or cantilever action, in a reduced gravity section. The simple vertical beam action is relatively about four times more efficient than cantilever action. Such action therefore would be helpful to gravity action and permit more load to be put on gravity action without producing tension in the up-stream face of the dam. It also helps in distributing the water pressure over the horizontal arch slices, tending to make the unit stresses in the arches more nearly uniform, as well as helping to transmit some water pressure quite directly into the rock bottom.

The various forces acting in arch dams make them, as the author has stated, "statically complicated structures", and he evidently appreciates the difficulties of an exact mathematical solution by a general formula that would be of practical value.

In the thicker bottom portions of the arch dam, shearing stresses—mostly horizontal and inclined, but some vertical—are a material factor in transferring the loads into the rock. The concrete near the bottom is so massive that the unit stresses in shear are relatively small, even for transmitting the greater part of the bottom water pressure. The principal resisting forces acting in arch dams are shear—horizontal, vertical, and inclined; simple gravity action; horizontal and inclined arch action; simple vertical beam action; some horizontal beam action; and cantilever action. On the principle of least work, all these different forces do work in proportion to their relative efficiencies or rigidities. With all these resisting forces marshaled, one may perhaps cease to wonder that arch dams have not failed.

Considering the dam as simply supported at the base, the deflection due to gravity action can be determined with a close degree of approximation, starting from the resultant pressure curve constructed by considering the weight of the masonry, the water pressure, and a reasonable allowance for uplift. The proper allowance for uplift depends on the character of the foundation. Some engineers (though probably few) advise allowance for uplift equal to the full static head on the base of the dam, or, in other words, that the dam is floating on water, which is impossible. Other engineers advise an allowance for uplift equal to the full static head at the up-stream edge,

decreasing to zero at the down-stream toe of the dam. This is more reasonable; but the writer is of the opinion that it is more than necessary in many cases.

Where the foundation is sound, solid rock, where dense concrete is used, and a thick layer of soft mortar is spread over the surface of the rock before the concrete is placed, an allowance for uplift equal to half the static head at the up-stream edge of the dam, decreasing to zero at the toe, or better to the ground-water level at the toe, if the ground-water level is above the toe of the dam, will prove sufficient for full gravity section dams.

In arch dams, horizontal arch action and vertical uplift act at right angles to each other. Therefore, theoretically, uplift does not directly affect horizontal arch action. Practically, however, uplift diminishes the efficiency of gravity action and thereby throws more work on arch action. Owing to the probability of a little tension in the up-stream face of arch dams before much arch action becomes effective, allowance for uplift in arch dams should be fully as much as for full gravity sections. The engineer must use his judgment as to how much allowance should be made for uplift in any special case.

The writer believes that in the allowance for ice pressure there has been a tendency sometimes to over-estimate its importance. It is a well known principle of physics that pressure produces heat, and the melting of ice by pressure applied on it is one of the familiar demonstrations of the principle. If through a rise in temperature, severe pressure, acting slowly, should be caused by ice, the latent heat developed at the point of contact would tend to soften the ice and relieve the pressure. In special cases, allowance for ice pressure may be desirable, but in most instances, no special allowance is necessary. Any possible ice pressure will be sufficiently cared for by the usual factor of safety of about two.

Before constructing the resultant pressure curve, a load curve should be assumed for the gravity action of the individual horizontal sections into which the dam is assumed to be divided. The assumed load curve should be such that the moments would show practically no tension in the up-stream face of the dam; and such that the greatest efficiency will result in the resisting forces on the principle of least work. Two or three trials will probably be necessary to obtain the best results.

For convenience in interpreting results, a percentage curve can be used, by constructing to a convenient scale, a rectangle on the back of the section of the dam, so that with horizontal lines drawn from each of the joints considered, the total length of the line or ordinate will represent 100%, or the total load on each joint. The best percentage load curve for gravity action will not be a vertical line, but a curved line. The center of pressure for each horizontal section into which the dam is assumed to be divided must be determined, in order to obtain the moments from water pressure. The depth of the center of pressure for each section, from the surface of the water or top of the dam, can be determined by the well known formula,

$$\text{Depth from surface} = \frac{2}{3} \times \frac{d_1^3 - d_2^3}{d_1^2 - d_2^2}$$

in which d_1 = depth from the surface of the water to the top of the section considered, and d_2 = depth from the surface of the water to the bottom of the section considered. By subtracting the result obtained by this formula, from the height of the dam, or from the distance from the base of the dam to the surface of the water, the moment arm for each section, with center of moments at the base of the dam, will be given. These moment arms grading off gradually for equal heights of section, are easily checked by first and second differences—second differences for the upper half of dam, and first differences for the lower half.

It will be convenient to have first, the moments of the water pressure at each section for the total water-pressure load, from which the moments for the percentage load curve easily follow. It will be helpful in checking to remember that with the center of moments at the base of the dam, the moment of water pressure is greatest at the center of the dam—the moments grading off gradually toward the top and equally from the center toward the base.

When the percentage load curve has been adjusted so that the overturning moments do not produce appreciable tension in the up-stream face of the dam and the resultant pressure curve for gravity action has been constructed, the extreme fiber stresses in the down-stream and up-stream faces of the dam at each joint can be determined from the nearest edge distance from where the resultant pressure curve cuts the joint.

The well known general formula for the greatest unit pressure is:

$$p = \frac{2\,N}{d}\left(2 - \frac{3\,e}{d}\right)$$

in which

p = the greatest unit pressure;
N = the normal component of all the external forces acting; and
d = the depth of the joint, or thickness of the dam at the joint.

This general formula can be simplified considerably for special cases.

Having found for each section the maximum unit fiber stress, which will be generally at the down-stream face of the dam, the unit stress in the opposite face follows by substituting for e, in the formula, the longest edge distance from where the resultant pressure curve cuts the joint, or from similar triangles, assuming, of course, that the stress varies uniformly across the section. If the resultant pressure curve falls outside of the "middle third", the opposite face stress will be tension.

Assuming a suitable elastic modulus for the concrete and considering the bottom section of the dam, the shortening of the down-stream and up-stream faces resulting from the compression can be found in the usual way; or, a little easier, by taking the difference between the compression at the down-stream and up-stream faces of the section, the shortening that would cause deflection at the top joint of the section easily follows. The deflection equals the shortening multiplied by the height of the section divided by the thickness of the base. This deflection of the bottom section only can be extended by simple proportion up through the different sections and to the top of the dam.

Proceeding to second section from the bottom, the deflection of this section from the normal to the bottom section can be determined in similar manner. Similarly, the deflections throughout the height from all the individual sections can be determined. The algebraic sum of all the different sectional deflections will give the total deflection at the different elevations of the gravity section.

If the resultant pressure curve near the top of the dam falls on the up-stream side of the center line of the dam, owing to differences in batter on the up-stream and down-stream faces of the dam, the top sections where the resultant pressure curve is up-stream from the center line of the dam will have a slight minus or up-stream deflection. This, however, is greatly over-shadowed by the much larger down-stream deflections of the individual sections lower down. So that the resultant deflection curve with reservoir full will be generally down stream from the normal. When the reservoir is empty, there is an initial up-stream deflection to be considered, as the unit stresses from weight will be greater in the up-stream than in the down-stream face, due to differences in batter in the two faces.

The deflections from arch action must be the same as in the gravity section, because they are in the same structure. Knowing the deflections, the corresponding unit stresses that would produce them can be determined from the deflection formulas of Silas H. Woodard, M. Am. Soc. C. E.,* or B. A. Smith, M. Am. Soc. C. E.,† by transpositions.

The Woodard formula is:

$$D = \frac{l}{2} \cot a,$$

in which,

D = the crown deflection;
l = the shortening of the arch ring under compression; and
a = one-quarter the subtending angle of the arch ring.

It will be found that although the actual deflections at the different sections vary greatly from top to bottom of the dam, a coefficient of deflection, that is, the multiplier of the unit stress, is nearly constant for the different sections and for the usual subtending angles. Probably quite as nearly constant as the elastic modulus would be.

Short-cut methods, therefore, can be used in special cases. For instance, the writer found that for a dam with a radius of extrados of 275 ft., the deflection, in inches, was about 3% of the unit stress, in tons, for arch action. This gave a simple and quick way of comparing the results of variations in the load curve and dam section. If the deflections are known, the unit stresses easily follow and *vice versa*.

Deflection caused by drop in temperature can be investigated in a similar manner, if the temperatures of the different parts of the dam can be determined. The author's suggestions for more data on the actual deflections of

* "Analysis of Stresses in Lake Cheesman Dam", by Silas H. Woodard, M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. LIII, p. 108.

† "Arched Dams", by B. A. Smith, M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 2027.

arched dams might well be applied also for more data of temperature measurements in dams. By means of the simple methods outlined, but with a few trials, almost any of the properties of any assumed section for a dam can be determined with a sufficiently close approximation for practical purposes. The accuracy of the well known cylinder theory as applied to thin cylinders unrestrained at the base is easily demonstrated. When applied to thick masonry dams, restrained at the base and in competition with more efficient resisting forces, however, it has its limitations. Nevertheless, the simple cylinder theory for arch dams is too useful for preliminary work and approximate estimates to be scrapped at present. It can be made simple and attractive by short-cut methods for application to special cases, for approximate results.

For instance, to illustrate its great simplicity of application in special cases: If the radius of the extrados of the arch is 320 ft., the stress, in tons, by the cylinder theory, at any horizontal arch slice 1 ft. thick, at a depth of h ft. from the surface of the water, would be, stress $= 10 \times h$. If the radius is 160 ft., it would be, $5 \times h$. This illustrates also the importance of as small a radius for the arch, as is practicable.

Even for approximate purposes, the cylinder theory must be used with judgment and with low unit stresses in compression. If the unit stresses vary from a little less than 10 tons per sq. ft. to a maximum of not more than 20 tons per sq. ft., in the different horizontal sections of the dam, the results will probably be safe and not extravagant. However, more accurate methods for important matters should also be used in the interests of economy and certainty of results, as the author has suggested.

It has been intimated somewhere that wedge action is the chief resistance in the bottom portions of the arch dam. A curved wedge, however, is essentially an arch. The faces of the wedge cannot slide wedge-like on the sides of the valley, but are cemented to the rock. It is as logical to assume, in pure horizontal arch action, that the bottom horizontal arch slices are free to slide on each other, as to assume that the slices higher up are free to slide. Practically, none of them actually does slide and cannot slide. Shearing strength is sufficient to prevent that. The fact is that arch action in the bottom portions of the dam, is outclassed by more efficient resisting forces.

The writer is of the opinion that tension in the up-stream face of arched dams should be limited to a maximum of about 50 lb. per sq. in. Generally, the dam would be cemented into the rock bottom at the up-stream edge to a depth of several feet, which would give some shearing resistance and permit a small allowance for tension in the up-stream face. It should be noted that there is comparatively little opportunity for arch action, until there is a little tension in the up-stream face of the dam. The percentage of the load that would be carried by arch action depends on the conditions. Without tension, however, in a extrados of 275 ft. radius, considered by the writer, it would be about 70% at the top, dropping down rapidly to about 10% at mid-section and to less than 1% near the bottom.

Arch action is most efficient at the top of a dam. Cantilever action is least efficient at the top. Simple vertical beam action, by carrying some bottom load to the upper horizontal arches as well as much more into the rock

bottom, utilizes arch action where it is most efficient. Gravity action is the most efficient in all the middle sections and takes care of much the greater part of the load. Where the cross-section of the valley is of a rather flat V-shape, flattening out at the top, it will generally be economical to locate a portion of the ends of the dam on tangents to the main central arch. The radius of the arch should be made as small as practicable, the stress being directly proportional to the radius.

Shortening the radius of a dam of the constant radius type tends to bring the ends around parallel to the contours on the sides of the valley. Making a portion of the ends on tangents to the main central arch tends to cut the contours more nearly at right angles and shortens the dam. These tangents, of course, should be of full gravity section; but if the top of the arch dam has a substantial, or practically full gravity section, it would work in nicely on the shallow ends.

The constant radius dam with tangent abutments is an approach toward the ingenious "constant angle dam" of L. R. Jorgensen, M. Am. Soc. C. E. The "constant angle dam" will generally be more economical of material; but as nearly all the surfaces up stream and down stream are substantially warped surfaces, the construction difficulties are slightly greater and the appearance generally less pleasing. The "constant radius dam with tangent abutments" is between the "constant radius dam" and the "constant angle dam", and is likely to be the most satisfactory in many cases, all things considered.

Topographical conditions, of course, would determine the most suitable type of dam for any particular location. As the radius of the arch increases, due to topographical conditions, the reduced gravity section approaches the full gravity section, and when the radius is much more than 300 ft., or the length is more than would be subtended by an angle at the center of about 120°, a full gravity section would probably be advisable.

There is no question but that a straight gravity dam, with good design, good materials, and workmanship can be made entirely safe. If the arched plan costs materially more, due to increased length, or any other reason, it could not in general be justified. If, however, the arched form costs no more than the straight gravity dam, it would undoubtedly be justified, as giving an added insurance against failure, because if, for any reason, gravity action fails, arch action stands by, competent to do the work. Ordinarily, however, arch action does not get much opportunity to work until there is some tension in the up-stream face of the dam. This is particularly true for the bottom portions where arch action is surpassed and greatly relieved by more rigid resisting forces.

The writer trusts that the author's appeal for data on the deflections of dams will produce results; and that he will continue his good work in developing and simplifying mathematical expressions for the properties of arch dams. Measured deflections to be of value must be taken with great accuracy. The striking feature about the matter is the relatively minute deflections compared with the enormous forces involved.

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PAPERS AND DISCUSSIONS

A REVIEW OF IMPORTANT DEVELOPMENTS IN THE SCIENCE OF CADASTRAL RESURVEYS AS EXECUTED BY THE UNITED STATES GOVERNMENT, WITH ETHICAL DISCUSSION THEREOF

Discussion*

By Messrs. W. J. Lightfoot, Clay Tallman, and S. V. Proudfit.

W. J. Lightfoot,† Assoc. M. Am. Soc. C. E. (by letter).‡—The author has shown a wide grasp of a complex subject, and his masterly treatment is not a surprise to those who are familiar with his professional work. Supplementing the statement of improved methods used by cadastral engineers in field work, some of the methods that have been used by the writer may be of interest.

Several direct altitude observations on the sun for azimuth may be taken in a few minutes, but to hold a field party while they are being reduced is a trying experience for one who is endeavoring to accomplish something more than just the taking of observations. One method used to avoid reductions in the field is to take a series of direct observations on the sun each afternoon and reduce them in camp. This makes a reliable check on the results obtained by the use of the solar.

If an observation must be reduced in the field, it is often possible to do a large part of the calculation before leaving camp, as follows:

The time and place of starting work is generally known, and the latitude of the place and declination of the sun may be obtained, therefore, in the formula,

$$\cos A = \frac{\sin \delta}{\cos \phi \cos h} - \tan \phi \tan h$$

the logarithmic functions can be arranged for the entire reduction, except the cos h and tan h, which may be done quickly in the field after taking the observation.

A plat of the lines to be surveyed on a certain day may be prepared, showing each minute of latitude with its log cos and log tan, as well as a table of the declinations of the sun for each hour with log sin. When the data are

* Discussion of the paper by Howard Richards Farnsworth, Assoc. M. Am. Soc. C. E., continued from January, 1922, *Proceedings*.

† U. S. Cadastral Engr., Washington, D. C.

‡ Received by the Secretary, January 9th, 1922.

arranged in this manner, it is easy to interpolate for a fractional part of a mile or for a fractional part of an hour. After an observation is taken, the only additional reference to the tables is for cos h and tan h.

For all practical purposes, it may be assumed that the ratio of the differences of the vertical angles to the differences of the horizontal angles is constant for one set of observations when the time elapsing between the taking of the first and the last observation is only a few minutes. When several observations are taken, before selecting those to be reduced, find the differences in vertical angles and the differences in horizontal angles. Then, to obtain the ratio, divide one by the other and select those for reduction that agree to the second or third decimal place. In this way, an erroneous observation may be eliminated and not used to vitiate the entire set, as is the case when the mean of a set is used in the reduction.

When the sun, moon, planet, or star is due east or west of the observer, it is said to be on the prime vertical. The altitude and hour angle may be obtained by the following formula:

Let P = hour-angle.
ϕ = latitude.
δ = declination.
H = altitude.

Then

$$\cos P = \cos \phi \tan \delta \text{ and } \sin H = \frac{\sin \delta}{\sin \phi}$$

The sun comes to prime vertical in northern latitudes only when its declination is north; therefore, the method can be used for solar observations only for a part of each year.

With accurate local mean time, it would be possible to use a tabulation of the azimuth of the sun made for each 10 or 15 min. of time.

Clay Tallman,* Esq. (by letter).†—The purely technical side of this subject is not in the writer's line; however, during the eight years that he was Commissioner of the General Land Office, he gave much attention to its legal and practical aspects, from the standpoint of results and Governmental policy. As shown by the author, it was largely during this period that the practical experience of previous years became crystallized into settled and established principles and practice. The correct position of the "line fence" has always been a prolific source of controversy and litigation. When it is considered that, as a result of error, obliteration, or fraud, a condition of uncertainty as to property lines often affects large areas, frequently of great value, and, further, that in the public land States the survey lines usually constitute the boundaries of political sub-divisions, the necessity and importance of reducing the re-establishment of lines and corners to a scientific system, legal and practical in its operation, becomes at once apparent; this, the General Land Office has worked out, not in theory only, but as applied to literally thousands of actual cases in the field, presenting every conceivable complication. It

* Denver, Colo.

† Received by the Secretary, January 13th, 1922.

should not be concluded, however, from this that any engineer with a good general training and a "Manual" is competent to execute acceptable re-surveys; probably in no branch of engineering work are practical experience and good judgment more necessary.

The writer has no criticism to offer of the paper other than to point out that the chart (Fig. 1), on page 407,* and the text relating thereto, rather overstates the importance and position of the Division of Surveys, as compared with the field organization, the two branches being co-ordinate under the Commissioner. He would like, however, to emphasize one aspect of the subject not generally appreciated, namely, that in official Government land surveys there exists a unique combination of legal and engineering functions hardly ever found in connection with any other engineering activity. If correctly and legally made and approved, an official survey fixes and determines legal rights; otherwise, the operation fails of its purpose. The first essential of such a survey is lawful authority. The order and instructions for such a survey must emanate from the proper source; the work must be performed pursuant to law by officers qualified legally as well as professionally; and the completed work must likewise receive the approval of the proper officers of the Government. The legal and engineering features are thus inter-related and inter-dependent; one without the other renders the survey ineffective, being in the contemplation of the law no survey. When it comes to re-surveys, this matter of legality of action taken and methods pursued, becomes doubly important, because of the inherent complications and because the work must stand the scrutiny of the Department and, in litigated cases, of the Courts. It follows that the closest correlation of the legal and engineering branches of the work is necessary for practical operations; this is accomplished, and has been for more than a century, through the field and office organizations of the General Land Office, pursuant to the laws of Congress.

The consideration of the legal aspect of official surveys suggests a further observation deemed to be pertinent at this time. Much is being said about the re-organization of Government departments and bureaus, with a view to avoiding duplication and correlating activities; among other things, it is urged in certain quarters, that all surveying and map-making activities of the Government be consolidated in a single bureau, and to this end, it is proposed to separate the land-surveying branch from the General Land Office and place it in the proposed "engineering" bureau. From the foregoing, it is apparent that such a course would result in the destruction of a perfectly logical and necessary correlation of activities, in order to create one in name only. Although analysis of other factors affecting the matter, such as the primary purpose of land surveys as distinguished from other surveys, the percentage of the completion of the land surveys of the country as compared with others, the bearing and importance of the records of all former surveys, and economy and efficiency of operation, furnishes ample reasons why the proposed change should be regarded unfavorably, an adequate conception of the fundamental character of official land surveys, such as the writer has en-

* *Proceedings*, Am. Soc. C. E., November, 1921.

deavored to point out, should in itself be sufficient. Whatever justification there may be for a re-allocation of other Government activities, the entire matter of land surveys should remain a part of the General Land Office, where it has always been and where it belongs. The only material change in the existing plan of organization requiring action by Congress, which, in the writer's opinion, would be conducive to efficiency and economy in land-surveying operations, would be (*a*) to abolish the offices of Surveyors General and consolidate the work of those offices in the General Land Office at Washington; and (*b*) to provide for one Supervisor of Surveys who, under the direction of the Commissioner of the General Land Office, would have entire supervision of all land-surveying activities, both in the Washington office and in the field.

S. V. PROUDFIT,* ESQ. (by letter).†—The writer will discuss this paper from the viewpoint of the public land lawyer, who is interested primarily in the fact of surveys rather than in the means of their accomplishment. This is especially true in the present instance, because of the broad treatment of the subject by the author, in which the limitations imposed by applied science and the law of the land are equally recognized.

The assignment of a definite description by which the locus of a tract may be accurately known is an essential prerequisite to its disposition by the United States; but, until 1910, no means to this end had been devised, either by the Legislative or Executive Branches of the Government, better than the contract system, under which the lowest bidder undertook the survey of a specific area in accordance with instructions he might receive from the Commissioner of the General Land Office. So far as any development of high engineering talent in the Department is concerned, none could have been looked for under the old contract system, and practically none resulted. The employment of the best skill possible in charge of the surveying unit in the General Land Office could not reach beyond matters of organization, for the execution of the work ultimately went to the successful bidder for the contract, whose first interest was in the quantity of his work rather than in its quality. The accuracy of the work performed under such conditions, subjected to all the tests that could be used under the ever-increasing demand for public lands, was, at the best, not susceptible of a reasonable demonstration. This is not to say that the public land surveys during that period were not usually well made, only that they were not as well made as they would have been in the hands of a National body of engineers.

The adoption of the direct system at once provided a permanent foundation for the assemblage of a body of trained cadastral engineers, to whom could be entrusted the duty of executing the public surveys with the certainty that the latest methods of engineering science would be at the command of the Government. If difficulty had been experienced in securing satisfactory original surveys under the old system, it goes without saying that such difficulties were many times magnified when serious problems of

* Member, Board of Law Review, Washington, D. C.

† Received by the Secretary, January 25th, 1922.

re-survey were encountered. The necessity of protecting vested rights, as well as possible equities, in the work of restoration or substitution, called for the exercise of field control that was practically out of the question under the contract system; therefore, while it prevailed, legislation authorizing resurveys was, in effect, limited to cases where the interests of the Government were dominant. With the installation of the direct system of surveys, however, and the effective demonstration that the public service from thenceforward offered a new field to the trained surveyor, the value of such a body of Government experts received recognition at the hands of Congress in the Act of September 21st, 1918 (40 Stat. 965).

Under prior legislation, resurveys, for the most part, were only made in order properly to mark the boundaries of the public lands remaining undisposed of; but this Act is for the express purpose of furnishing a competent means for the re-establishment of boundaries of land the title to which had passed from the United States.

The first fruits, then, of the direct system of surveys was certainty in result, at less cost to the Government in the matter of original surveys, while the later result was the recognition of a disinterested scientific body of engineers to whom could be referred boundary disputes, by the Courts or individual land owners, and thus reduce to the minimum the consequences of unskillful or reckless field work that had received approval under the old system.

With the adoption of the present system of surveys, it became apparent that a new "Manual of Surveys" should be provided for the Service, and to this end a special committee formed in the Surveying Service of the General Land Office, made a careful study of the situation, its necessities as then existing, and the requisite provision for its future development. Practically, however, the relation of the "Manual" to the public surveys, the working instructions of the Commissioner of the General Land Office, who is charged with all executive duties appertaining to the survey of the public lands, is the same under the new system as under the old, and during the earlier period of transition, changes in procedure were covered by special instruction, and it was not until June 16th, 1919, that the first chapters of the new "Manual" were issued.

This apparent delay in the issuance of the new "Manual", aside from giving the new system an opportunity to develop special needs peculiar to itself, was also due to pending legislation with respect to resurveys, which finally took form in the Act of 1918.

Although all the features of the new "Manual" were given careful consideration from every viewpoint, technical, legal, and practical, when Chapter 6 was taken up, the new field of operations contemplated by the Act of 1918 called for special care in its preparation, and the final review of its provisions prior to adoption will long remain a memorable occasion to the participants in the discussion. With the Commissioner of the General Land Office presiding, an officer familiar with the public land laws from every angle, the special committee of cadastral engineers, and three members of the Board of Law Review, each with not less than twenty-five years' experience in the adjudication of Federal land questions, the tentative contents of the chapter were con-

sidered and discussed line by line through repeated sessions of many hours' duration, with the intent that not only should the public service receive the benefit of the last word in the science of land surveys, but that the vested interests and equities of land owners should be duly protected under the law as construed by the Courts of last resort.

It is a curious comment on the story of public lands and their disposal, that it was not until the greater part of them had been surveyed, and passed out of Federal ownership, that provision was made by which the officer charged with their survey was really so equipped with statutory authority as to insure accuracy in the work. This page, however, of the story is beyond recall, and well it is, for the protection of those who have taken title under the old system, that the protection of their boundaries is not left to the tender mercies of the contractor.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

BUCKLING OF ELASTIC STRUCTURES

Discussion*

By Messrs. Eugene E. Halmos, and Edward Godfrey.

Eugene E. Halmos,† M. Am. Soc. C. E. (by letter).‡—This paper is probably the most thorough treatise that the writer has seen on the theory of combined buckling and "cross-bending" of columns and slabs. The general theory applicable to other structural forms, so interestingly demonstrated, will also be appreciated by all students of mechanics of structures. The author is to be commended for indicating and illustrating the extreme usefulness of one of the best tools of higher mathematics, the Fourier series, in the solution of problems encountered in engineering design.

It is gratifying to note that the author has proven the formulas in general use for designing columns (Formulas (1), (2*a*), and (2*b*)) to be on the safe side by a considerable margin, except in the case of fixed end columns and distributed side loads (Case IV, Formula (5)). However, as designers will dimension the columns on the basis of maximum transverse moment, which, in the case of a fixed beam, occurs at the ends, it will be seen, by comparison with the author's Formula (6), that the use of the "approximate" formulas results in safe structures.

All the author's examples refer to the particular cases where "orthostatic" loading increases the effect of "astatic" action. There is, however, a case, often met in practice, where the opposite is true, namely, an upright thin cylinder or drum supporting a vertical load and being filled with a gas or liquid exerting a greater pressure on the wall than that of the surrounding air or liquid. The writer proposes to show the derivation of formulas for such a "heterostatic" loading. A slightly modified presentation of Professor Forchheimer's solution, published in a little known pamphlet,§ will be given. First, the equilibrium conditions of a cylindrical drum supporting only a vertical load will be derived, and then the influence of inside and outside pressures will be demonstrated.

* Discussion of the paper by H. M. Westergaard, Esq., continued from January, 1922, *Proceedings*.

† Designing Engr., Parsons, Klapp, Brinckerhoff and Douglas, New York City.

‡ Received by the Secretary, December 30th, 1921.

§ "The Berechnung Ebener und Gekrümmter Behälterböden", 1909.

A.—Buckling of an Upright Thin Cylinder Under a Load Distributed Along the Rim.—Quoting the author, "a thin cylindrical shell or tubular strut may buckle into a double-curved surface under the influence of a compressive load parallel to the axis" (page 460).* This form of failure will be treated by the writer, not the assymetrical buckling investigated by R. Lorenz in his paper referred to in the author's Bibliography, Part VII, Section *H* (page 532).*

In Fig. 16, let the circle drawn in full line represent the horizontal section of a vertical drum stiffened on top and bottom, the radius, r, being assumed to be large compared with the thickness of the shell, and let the dotted elliptical line be the same section after the drum has deformed under the influence of a compressive load distributed uniformly over the rim of the cylinder. Fig. 17 is a vertical section of the shell, the full lines representing the unstressed wall of a perfect cylinder, the dotted lines the deformed wall along Diameter A-A, and the dashed lines the deformed wall along Diameter B-B. If it is assumed that the shell consists of a large number of independent vertical strips, it is evident that, should a horizontal thin band be welded around the drum, this band would be pushed radially outward between the nodal points, N N', and radially inward between the points, N N, and N' N', by forces proportional to the distance of the elliptical contour from the original circular one (Fig. 16).

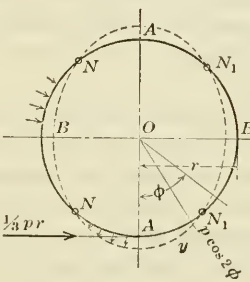

FIG. 16.

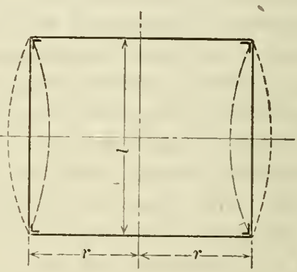

FIG. 17.

Consider a ring of unit height, sectional moment of inertia, I, modulus of elasticity, E, subjected to forces of the character described. Denoting with p the (unknown) maximum pressure intensity, the unit pressure at any point of the ring can then be expressed by,

$$p \cos 2\phi = p\,(2\cos^2\phi - 1)$$

in which ϕ is the angle between the vector and the radius, $O\ A$.

At A, where $\phi = 0$, we have a reaction:

$$p\,r \int_{-\frac{\pi}{2}}^{0} (2\cos^2\phi - 1)\sin\phi\, d\phi = p\,r \left[\frac{-2\cos^3\phi}{3} + \cos\phi\right]_{-\frac{\pi}{2}}^{0} = \frac{p\,r}{3} \quad (162)$$

and a moment, M_0, yet unknown.

At the point where $\phi = \phi_1$, the moment of all pressures between 0 and ϕ_1, will be:

* *Proceedings*, Am. Soc. C. E., November, 1921.

$$\int_0^{\phi_1} p\, r\, (2 \cos^2 \phi - 1)\, r \sin (\phi_1 - \phi)\, d\, \phi^*$$

$$= p\, r^2 \sin \phi_1 \int_0^{\phi_1} (1 - 2 \sin^2 \phi) \cos \phi\, d\, \phi - p\, r^2 \cos \phi_1 \int_0^{\phi_1} (2 \cos^2 \phi - 1) \sin \phi\, d\, \phi$$

$$= p\, r^2 \sin \phi_1 (\sin \phi_1 - \frac{2}{3} \sin^3 \phi_1) + p\, r^2 \cos \phi_1 \left(\frac{2}{3} \cos^3 \phi_1 - \cos \phi_1 + \frac{1}{3}\right)$$

$$= \frac{p\, r^2}{3} (- 2 \cos^2 \phi_1 + \cos \phi_1 + 1)$$

or, dropping the subscript,

$$\frac{p\, r^2}{3} (\cos \phi - \cos 2\, \phi)$$

to which the moment of the reaction, $\frac{1}{3} p\, r$, and M_0 should be added. The total amount, therefore, at the point, ϕ, will be:

$$M = M_0 + \frac{1}{3}\, p\, r^2 (1 - \cos \phi) + \frac{p\, r^2}{3} (\cos \phi - \cos 2\, \phi)$$

$$= M_0 + \frac{2}{3}\, p\, r^2 \sin^2 \phi \qquad \text{(163)}$$

According to Boussinesq,† the deformation of a ring generally follows the law:

$$y + \frac{d\, y^2}{d\, \phi^2} = \frac{M\, r^2}{I\, E} \qquad \text{(164)}$$

Substituting the value of M from Formula (163), we have the differential equation:

$$\frac{I\, E}{r^2} \left(y + \frac{d^2 y}{d\, \phi^2}\right) = M_0 + \frac{2}{3}\, p\, r^2 \sin^2 \phi$$

the integral of which is:

$$\frac{I\, E}{r^2}\, y = M_0 + \frac{2}{9}\, p\, r^2 (1 + \cos^2 \phi) + C_1 \sin \phi + C_2 \cos \phi$$

in which C_1 and C_2 are the constants of integration.

By hypothesis (Fig. 16):

$$\frac{I\, E}{r^2} \cdot \frac{d\, y}{\delta\, \phi} = - \frac{4}{9}\, p\, r^2 \sin \phi \cos \phi + C_1 \cos \phi - C_2 \sin \phi$$

must vanish for both $\phi = 0$ and $\phi = \frac{\pi}{2}$, making $C_1 = C_2 = 0$, and,

$$\frac{I\, E}{r^2}\, y = M_0 + \frac{2}{9}\, p\, r^2 (1 + \cos^2 \phi) \qquad \text{(165)}$$

M_0 can now be solved by applying the condition that the length of the circumference of the ring remains unchanged when the shell is deformed,

* The change in the length of r, due to the deformation of the shell, is neglected. This is permissible because this deformation, compared with the radius (which is assumed to be large), is very small before failure occurs. Consequently, the forces, $p \cos 2\, \phi$ are also small.

† *Comptes Rendus*, Vol. 97 (1883) p. 843.

that is,

$$\frac{I\,E}{r^2}\int_0^{\frac{\pi}{2}} y\,d\,\phi = \left[M_0\,\phi + \frac{1}{9}\,p\,r^2\,(3\,\phi + \sin\phi\cos\phi)\right]_0^{\frac{\pi}{2}} = 0$$

$$M_0 = -\frac{1}{3}\,p\,r^2 \quad \ldots\ldots (166)$$

which value, substituted in Formula (165), results in

$$y = \frac{p\,r^4}{9\,I\,E}\,(2\cos^2\phi - 1) = \frac{p\,r^4}{9\,I\,E}\cos 2\,\phi \quad \ldots\ldots (167)$$

representing the deformation of a ring radially loaded with forces, $p \cos 2\,\phi$.

Consider, now, a vertical strip of the drum shell, of unit width and length (or height) l, which buckles under a load, Q. Such buckling will be resisted by the horizontal rings with forces proportional to the deformation of the vertical strip. It is assumed that the cylindrical wall of the drum is able to turn freely (in other words, is hinged) at the top and bottom about the stiffening rings. From the theory of buckling of columns, it follows that the strip will deform into a half wave of a sine curve (Fig. 18), and, denoting by q the maximum intensity of the resistance exerted by the rings, the unit pressure resisting the buckling at a height, x, above the base of the strip is given by:

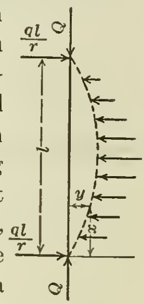

FIG. 18.

$$q\,\sin\frac{\pi\,x}{l}$$

The reactions at the top and bottom of this strip, corresponding to these horizontal forces, will be:

$$\int_0^{\frac{l}{2}} q\,\sin\frac{\pi\,x}{l}\,d\,x = \left[-\,q\,\frac{l}{\pi}\cos\frac{\pi\,x}{l}\right]_0^{\frac{l}{2}} = \frac{q\,l}{\pi} \quad \ldots\ldots (168)$$

The total moment at the point, x_1:

$$M = Q\,y + \int_0^{x_1}(x_1 - x)\,q\,\sin\frac{\pi\,x}{l}\,d\,x - \frac{q\,l}{\pi}\,x_1 = Q\,y$$
$$-\left[q\,x_1\,\frac{l}{\pi}\cos\frac{\pi\,x}{l} - q\,\frac{l}{\pi}\,x\cos\frac{\pi\,x}{l} + q\,\frac{l^2}{\pi^2}\sin\frac{\pi\,x}{l}\right]_0^{x_1}$$
$$-\,q\,\frac{l}{\pi}\,x_1 = Q\,y - q\,\frac{l^2}{\pi^2}\sin\frac{\pi\,x_1}{l} \quad \ldots\ldots (168a)$$

With the notation used, the differential equation of the elastic line becomes,

$$I\,E\,\frac{d^2\,y}{d\,x^2} = -\,Q\,y + q\,\frac{l^2}{\pi^2}\sin\frac{\pi\,x}{l} \quad \ldots\ldots (169)$$

the solution of which, considering that y must vanish for both $x = o$ and $x = l$, can be written as:

$$y = \frac{q\,l^4}{\pi^2\,Q\,l^2 - \pi^4\,I\,E}\sin\frac{\pi\,x}{l} \quad \ldots\ldots (170)$$

Now, by hypothesis,

$$p\cos 2\,\phi = q\,\sin\frac{\pi\,x}{l}$$

and y in Formulas (167) and (170) is identical, therefore,

$$\frac{r^4}{9\,I\,E} = \frac{l^4}{\pi^2\,Q\,l^2 - \pi^4\,I\,E}$$

from which the critical load which can be supported on the unit length of the rim of a thin cylinder of given r, l, I, and E, is:

$$Q = \frac{\pi^2\,I\,E}{l^2}\left(1 + \frac{9\,l^4}{\pi^4\,r^4}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots (171)$$

If the thickness of the shell is t, then $I = \frac{t^3}{12}$ and Formula (171) becomes,

$$Q = \frac{t^3\,E}{l^2}\left(0.822 + 0.076\,\frac{l^4}{r^4}\right)\ldots\ldots\ldots\ldots\ldots\ldots (171a)$$

It will be noted that for $r = \infty$, Formula (171) reverts to the well known Euler formula for columns hinged at the top and bottom. The influence of Poisson's ratio was neglected in the derivation of Formula (171), so that the value of Q is slightly on the safe side.

B.—Buckling of an Upright Thin Cylinder Under a Load Distributed Along the Rim and Supporting a Uniform Radial Inside Pressure.—The ring of unit height previously considered is assumed to support inside radial forces of constant intensity, p_1, the magnitude of which is large compared to $p \cos 2\,\phi$. This inside pressure results in a ring tension, $T = p_1\,r$, tangent to the original circular contour and, therefore, acting with a lever, y, on the displaced elements of the deformed ring, Fig. 19. The moment equation, Formula (163), therefore, changes to:

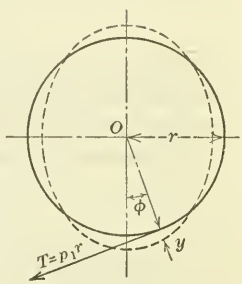

FIG. 19.

$$M = M_0 + \frac{2}{3}\,p\,r^2 \sin^2\phi + T\,y\ldots\ldots\ldots\ldots\ldots\ldots (172)$$

and the differential equation of the elastic line to:

$$\frac{I\,E}{r^2}\left(y + \frac{d^2\,y}{d\,\phi^2}\right) = M_0 + \frac{2}{3}\,p\,r^2 \sin^2\phi + T\,y\ldots\ldots\ldots\ldots (173)$$

Noting that $\frac{d\,y}{d\,\phi}$ vanishes for $\phi = 0$ and $\phi = \frac{\pi}{2}$, as seen in Fig. 19, the integral of Formula (173) can be written as:

$$y = \frac{r^2\,M_0}{I\,E - T\,r^2} + \frac{4}{3}\,\frac{I\,E\,p\,r^4}{(I\,E - T\,r^2)\,(3\,I\,E + T\,r^2)} - \frac{2}{3}\,\frac{p\,r^4 \sin^2\phi}{3\,I\,E + T\,r^2}.\,(174)$$

which can be readily proven by forming $\frac{d^2\,y}{d\,\phi^2}$ and substituting this and the expression for y in the left-hand member of Formula (173).

The condition that the length of the quadrant remains unchanged will give the value of M_0:

$$\frac{I\,E - T\,r^2}{r^2}\int_0^{\frac{\pi}{2}} y\,d\,\phi = M_0\,\frac{\pi}{2} + \frac{4}{3}\,\frac{I\,E\,p\,r^2}{3\,I\,E + T\,r^2}\,\frac{\pi}{2}$$
$$- \frac{2}{3}\,\frac{I\,E - T\,r^2}{3\,I\,E + T\,r^2}\,\frac{\pi}{4}\,p\,r^2 = 0$$

from which, as before,

$$M_0 = -\frac{1}{3} p\, r^2$$

and, finally,

$$y = \frac{1 - 2 \sin^2 \phi}{3\,(3\,I\,E + T\,r^2)} p\, r^4 = \frac{p\, r^4}{3\,(3\,I\,E + T\,r^2)} \cos 2\,\phi \text{.......} (175)$$

Formula (175) holds simultaneously with Formula (170),

$$y = \frac{q\, l^4}{\pi^2\, Q\, l^2 - \pi^4\, I\, E} \sin \frac{\pi\, x}{l}$$

in which, again, $q \sin \frac{\pi\, x}{l}$ is identical with the forces, $p \cos 2\,\phi$, developed in the ring and resisting distortion; the inside pressure, p_1, is in equilibrium with the tangential tension, T. Therefore, eliminating y between Formulas (170) and (175), and solving for Q, we get:

$$Q = \frac{\pi^2\, I\, E}{l^2} \left(1 + \frac{9\, l^4}{\pi^4\, r^4}\right) + \frac{3}{\pi^2} \frac{l^2}{r^2} T \text{................} (176)$$

indicating, by comparison with Formula (171), the substantial increase in the critical load which can be supported on the rim of a drum when inside pressure is acting.

In terms of the thickness of the wall:

$$Q = \frac{t^3\, E}{l^2} \left(0.822 + 0.076 \frac{l^4}{r^4}\right) + 0.304 \frac{l^2}{r^2} T \text{........} (176a)$$

C.—Buckling of an Upright Thin Cylinder Under a Load Distributed Along the Rim and Supporting a Uniform Radial Outside Pressure.—An outside pressure of intensity, p_2, will produce a tangential compressive force, $P = p_2\, r$, in the ring. The critical load which can be supported by the drum, by the same reasoning as demonstrated, in Section B, can be written as:

$$Q = \frac{\pi^2\, I\, E}{l^2} \left(1 + \frac{9\, l^4}{\pi^4\, r^4}\right) - \frac{3}{\pi^2} \frac{l^2}{r^2} P \text{..............} (177)$$

or, in terms of the thickness of the shell,

$$Q = \frac{t^3\, E}{l^2} \left(0.822 + 0.076 \frac{l^4}{r^4}\right) - 0.304 \frac{l^2}{r^2} P \text{........} (177a)$$

This formula shows the substantial decrease in the supporting power of a drum or tubular strut when under outside pressure, and it also shows that buckling may occur even though no vertical load is applied, if,

$$P = \frac{\pi^4\, I\, E\, r^2}{3\, l^4} \left(1 + \frac{9\, l^4}{\pi^4\, r^4}\right),$$

or,

$$p_2 = I\, E \left(\frac{3}{r^3} + \frac{\pi^4\, r}{3\, l^4}\right) \text{......................} (178)$$

and, in terms of the thickness of the shell, if,

$$p_2 = \frac{t^3\, E}{r^3} \left(0.25 + 2.706 \frac{r^4}{l^4}\right) \text{..................} (178a)$$

A cylinder of length, l, without stiffening rims, must behave in the same manner as one infinitely long with stiffened ends; substituting $l = \infty$ in Formula (178), we get, for the buckling load of cylinders with outside radial pressure,

$$p_2 = \frac{3\,I\,E}{r^3} \qquad (179)$$

which simple formula was first given by Boussineq.*

EDWARD GODFREY,† M. AM. SOC. C. E. (by letter).‡—This paper enriches the science of column mathematics with new formulas and new views as well as new terms. The writer believes it is a legitimate criticism of the paper to state that it does not offer much help to the practical designer. Only a few men in the profession, outside of the colleges, will be able to follow this paper or even to understand and use the formulas derived.

The writer has searched the paper for a formula that would give the theoretical collapsing pressure on a thin tube subjected to external pressure, but could not find it, although the Synopsis holds out the promise that this problem, among others, is solved.

As an example of the problem that faces the designer, take Table 2, in which the relation between the total moment on a column subject to bending, to the moment from bending alone is given. Here one finds that a certain fraction of the Euler load exerted endwise on a column, will increase by a definite ratio any moment due to lateral loads, regardless of what the moment from lateral load may be. To know this is useful if it has application in a practical design, but what the designer wishes to know is, what end load or what side load may be allowed against a column and still be safe in the design. He also wishes to know to what class of columns Table 2 should be applied.

For example, if a factor of safety of 5 on the Euler load is used in the case of a hinged end column with a center side load, the moment due to the side load will be increased 20 per cent. Will the column be safe? Or, suppose the column is slender and a factor of safety of 1.8 is considered sufficient, the end load will double the moment from the side load, regardless of what that moment may be. European engineers use the Euler formula for designing columns with a factor of safety of 5. In America many long derrick booms are designed that have an actual factor of safety of 1.5 or 2 and the weight of the boom furnishes the lateral load; or the dead end of the boom line may be attached to the middle of the boom, and the upward force may exceed the boom weight.

Between these two extremes there must be a medium that represents safe and economic design. The European practice of using the Euler formula with a factor of safety of 5 cannot be defended; because the Euler formula does not give even an approximation of the ultimate strength of permissible structural columns, and a factor of safety of 5 for slender columns, where the Euler load does apply, is entirely too large and results in a waste of material.

* *Comptes Rendus*, Vol. 97 (1883), pp. 844 and 1131.

† Structural Engr., Robert W. Hunt and Company, Pittsburgh, Pa.

‡ Received by the Secretary, January 12th, 1922.

As the author points out, there is not a start of failure in a slender column until the Euler load is nearly reached. Why, therefore, should there be such a wide margin between the working load and the ultimate? In permissible structural columns there is actual unit stress which is a good fraction of the actual elastic limit of the metal, therefore, the factor of safety should be of some magnitude to take care of overload and of the so-called fatigue of the metal. In slender columns, the actual unit stress under a factor of safety of 5 may be as little as one-fiftieth of the elastic limit or less. This is one of the cases pointed out by Professor Westergaard, where increased load and increased deflection are not directly proportional. There is a sudden jump to the ultimate.

It is of the utmost importance that designers should be familiar with the following facts concerning column design, namely, the inapplicability of slender column formulas to short columns and the equal inapplicability of formulas for short columns to the design of long columns. The author does not distinguish between short and long columns, nor does he state that the formulas given have an application chiefly, if not solely, to slender members. Increased deflection in slender columns gives rise to increased bending moments due to the endwise load. In admissible structural columns, however, the deflection due to externally applied loads is small.

The author does not recognize nor provide for imperfections in columns. In the writer's judgment, no treatment of the strength of columns can be of definite value, which does not recognize the fact that columns are imperfect, and the imperfections have a great influence on their strength. Perfect columns, perfectly loaded, would have a strength greatly in excess of commercial columns, loaded in the manner feasible in practice; this refers to structurally permissible columns and not to slender members. Furthermore, the nature of the imperfection assumed must be possible or one that can be defended.

The Gordon formula for columns is based on the assumed imperfection of the column. The imperfection is a bow or deflection in the column directly proportional to the square of the length and inversely proportional to the depth of the column cross-section, and this imperfection is "frozen" in the column, that is, increased deflection due to application of the end load is ignored. Let these assumptions be examined. For example, suppose a column is 5 ft. long, has an offset of 0.2 in. or $\frac{1}{300}$ of the length. This column might pass for straight. Now, take a column of the same cross-section 50 ft. long; to agree with the Gordon formula the deflection would be 100 times as great, or 20 in. This column would be bowed, and the imperfection would be so great that the case would not be classed as simple column action. In this case, what the author points out as being true in some cases, namely, that stress is not proportional to load, is of prime importance.

A coefficient determined by test on a short column, for insertion in the Gordon formula, would give a value based on compressive strength of the steel, and elasticity or buckling of the column as a whole, would have little effect; whereas a coefficient for a slender column would be controlled entirely by the elastic properties of the steel, the properties beyond the elastic limit having

no effect whatever. Obviously, no agreement could possibly exist between these two columns that a formula of the Gordon type could reconcile.

A great deal of the column mathematics is useless, because it fails to recognize column facts and deals solely with the theory of the ideal column. Any chart of tests on columns will show that a definite column formula for the ultimate strength of a column is impossible. The wide variation between test results of columns of similar properties is the proof of this.

The writer has published* a paper on the strength of columns, which, in effect, gives a rational derivation of the straight-line formula. The formula derived, though complex, has a locus that coincides almost exactly with the commonly used straight-line formula for ratios permissible in structures. The only assumptions are that the unit stress on the extreme fiber of the column is 16 000 lb. per sq. in. and that the column is imperfect. The imperfection is a bow in the axis of the column, the offset being $\frac{1}{300}$ of the column length. Increased deflection due to endwise load is taken into account as the author has done in his investigations. This article is re-printed in the writer's book, "Steel Designing", and is believed to be the only attempt to demonstrate the straight-line formula as a rational formula. The author apparently did not consider this paper of sufficient merit to mention it in his Bibliography. It would seem that a demonstration of the rationality of the one formula used universally in America for columns, would be worthy of recognition if only to prove its falsity if it is falsely derived. It is just as important to point out the errors of the literature on the subject as to emphasize the merits.

In the Synopsis of the paper, the fact is recognized that a straight, homogeneous and elastic column will reach a point where it bends out suddenly. This is called the critical value. In the body of the paper, it is shown that this point of sudden bowing is the Euler load. In the "Introduction" it is stated:

"The neutral equilibrium, maintained at this constant critical load throughout a continuous range of increasing deflections, is the criterion of pure buckling. The load may be increased beyond the critical value at which the bending ordinarily begins, and still the column may be made to remain in equilibrium in an undeflected state."

The condition of a column at the Euler load, the author calls a "stable neutral equilibrium."

With this quotation from the "Introduction", and with the idea that a column at the Euler load is in a stable neutral equilibrium the writer cannot agree. It is of great importance that it be made clear that at the Euler load a column has reached its absolute ultimate load and is not in any kind of equilibrium. That a column is in equilibrium at the Euler load carries with it the idea of reserve strength, but it can be proven by mathematics that the Euler load is the ultimate load that a column can sustain.

The common derivation of the Euler relation finds that for any assumed deflection, the column remaining elastic, there is theoretical equilibrium be-

* *Railway Age Gazette*, July 2d, 1909.

tween the internal resistance and the applied load. From this, it is asserted that the column is capable of sustaining the Euler load at any assumed deflection. The truth is that this is merely the history of the failure of the column. When the Euler load is reached, the column begins to deflect measurably, and continues to deflect without increased load. Nothing could prevent the continuance of this deflection, after it is once started, unless it should be some other means of support for the load, and this is not admissible. There is nothing therefore to prevent the failure of the column.

The proof, referred to is this: Assume a column with hinged ends and having a bow with an infinitesimal offset—a straight column mathematically speaking. Let the curve of this assumed bow be a sine curve. Calculate the endwise load that will double the assumed infinitesimal bow, which load will double the bow an infinite number of times, and is the Euler load. This multiplication of the infinitesimal deflection means a finite deflection and failure. Thus, by an absolute proof, the column is shown to have reached its ultimate load. There is no room here for the conception of equilibrium.

The author asserts, however, that the column may assume a curve made up of a number of half-waves instead of one curve, which would mean that the column is perfectly regular in its imperfection, and would possess a tendency to bow in one direction for a segment of its length and the other direction in the next segment, and so on throughout its length. The points of inflection would have to be the same distance apart, and that distance, an exact multiple of the column length. The deflected segments would have to deflect the same amount, otherwise, there would not be a balance between the several segments at points of inflection, which would set up unbalanced forces and cause lateral motion. There is nothing in the nature of columns to warrant the assumption of such impossible conditions.

The author states in the quotation given previously that the column may be made to remain in equilibrium in an undeflected state with load beyond the critical value at which the bending ordinarily begins. If this means that the column may be made to carry more load by supplying lateral support, it is immediately placed in another class, where the formula has no application. In fact, there is no other way to make a column that has reached the Euler load, carry any more load except by supporting the column laterally, and thus vitiating the formula as regards that column.

The writer finds that few designers have any conception of the strength of slender columns and of the application of the Euler formula to the proportioning of columns. The reason for this is doubtless the character of the common mathematical treatment in books and in papers on columns. Another thing that has a great influence in the same direction is emphasis on the formulas and tests for structurally permissible columns. All of it may be summed up in the failure of writers to differentiate between slender and short columns, the failure to point out clearly the difference between their action under load, and also that in the zone where slender and short columns meet or overlap, the characteristics of each action must be properly considered and combined.

Mathematical writers have been too assiduous in their quest for a perfect column formula. Nothing but a perfect column would approximately measure up to their formula, particularly in structurally permissible column.

The "whip formula", presented in the writer's book, comes about as near passing through the middle of any group of tests as any curved-line formula in use. Since the handle of the whip, or the straight portion, is the only part that concerns structural designers it is eminently proper that a simple straight-line formula should be used for structural members. An example of how column tests group themselves around a straight line has been given.*

Designers of airplane struts and transmission towers deal with slender columns, and it is important that their characteristics should receive the attention of the Profession. Only recently the writer's attention was called to designs of transmission towers where high unit stresses were used in columns because of the special quality of the steel. Theory demonstrates that in slender compression members, carbon steel has little or no advantage over soft steel, as the modulus of elasticity is the only factor affecting the results. Tests also demonstrate the same thing.

The writer is unable to understand the author's formulas for square slabs supported on four edges. On page 480,† the intensity of the moment of such a slab is given as 0.042 wb^2. In other places, for example, Formula (36), it is given as 0.077 wb^2. Still another value, on page 478,† works out as 0.037 wb^2 for a square slab.

On page 478,† it is stated that in a slab that is square or nearly square, greater moments occur along and across the diagonals at the corners than at the center. How can a slab be subject to bending when and where it is in contact by hypothesis, with a rigid and straight support? At the corners, the slab is in contact with the supports, and could not bend either in the direction of the diagonal or transverse with it. Surely no one would reinforce a slab against bending in the corner, where there could be no deflection whatsoever and, therefore, no stress on the reinforcement. If any conceivable force could split the slab in the corner, diagonally, or pinch off the corner, what measurable effect would it have on the slab as a whole?

In the Bibliography, the author has neglected to mention some useful and practical tests on the collapsing pressure of tubes subject to external pressure, which tests‡ were made by Mr. R. T. Stewart, of the University of Pittsburgh.

* Figs. 1, 2 and 5, *Engineering News-Record,* March 10th, 1921, pp. 431-432.

† *Proceedings,* Am. Soc. C. E., November, 1921.

‡ *Transactions,* Am. Soc. Mech. Engrs., May, 1906.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

WINTER OVERFLOW FROM ICE GORGING ON SHALLOW STREAMS

Discussion*

By H. B. Muckleston, M. Am. Soc. C. E.

H. B. Muckleston,† M. Am. Soc. C. E. (by letter).‡—The phenomena, exhibited in ice and ice formation are of great material interest to hydraulic engineers and especially where their work is in altitudes or latitudes sufficiently high to make trouble from ice formation a matter of annual occurrence.

In spite of the valuable research work already done, there is room for a great deal more, and contributions to the knowledge of the subject are a welcome addition to science.

The *modus operandi,* causes, and effects of ice formations are still obscure, in many phases, notwithstanding its apparent simplicity. The formation of the so-called frazil is one subject on which the last word has not been said. It is possible to cool water to a temperature much below its freezing point, provided the water is absolutely still, for example, in a glass jar. Sudden agitation by shaking or even inverting the jar will cause it instantly to congeal. A similar action may sometimes be noted when large quantities of frazil float in practically still water without solidifying. Very slight agitation, such as that caused by the sudden opening of a submerged valve, may result in the instanteous freezing of the whole into a solid mass.

Anchor ice forms on the bed of shallow streams; but shallowness is a relative term, since anchor ice has been observed under 10 ft. of water. A similar formation sometimes occurs in flumes, particularly in those constructed of metal or concrete, and in metal pipes, entirely exposed to the atmosphere. Where the pipes rest on earth, it has also been noticed that anchor ice forms only on the part exposed to the air. It will form under bridges if the conditions are right.

The size of stones which at times are lifted by anchor ice is astonishing; one weighing 52 lb. has come under the writer's observation. It might also

* This discussion (of the paper by J. C. Stevens, M. Am. Soc. C. E., published in December, 1921, *Proceedings,* but not presented at any meeting of the Society), is printed in *Proceedings,* in order that the views expressed may be brought before all members for further discussion.

† Chf. Engr., Lethbridge Northern Irrig. Dist., Lethbridge, Alberta, Canada.

‡ Received by the Secretary, January 9th, 1922.

be noted that these stones may get into all sorts of unexpected places; in one case, a pear-shaped boulder became lodged in the groove of a Stoney gate, and had to be broken before it could be removed.

The statement that the transporting power of water varies as the sixth power of the velocity needs qualification. First, it refers to bodies of higher specific gravity than water; second, it refers to movement of any kind, not merely floating or apparent floating, such as may occur with suitably shaped objects in violent streams; as, for example, the locomotive which, serious witnesses were prepared to swear floated on the Johnstown flood. In so far as ice, or other light material is concerned, the transporting power depends on the depth. The eroding power of water in motion is another matter.

A phenomenon, which is observed in rivers in the "chinook belt" east of the mountains, is known as over-flooding. The less turbulent streams usually freeze over more or less completely, early in the winter. As the result of a continued cold snap, the discharge is somewhat reduced and, as a consequence, the ice in mid-stream sags perhaps several inches or even feet. A chinook increases the discharge rapidly to a quantity which the channel under the ice cannot accommodate, and as a result the water flows in a thin sheet over the ice and freezes. This results in extremely thick ice, especially on the edges, which is prone to remain solid long after the ice in the center is rotten. When it finally does float away, it is in excellent shape to cause jams in the first suitable place. In one case, on a stream much used for skating, this phenomenon was a regular afternoon occurrence on warm days. Skaters going up the river would meet a thin sheet of water about an inch or less in depth flowing down. This water was always frozen the next morning; but if the air was warm enough, that is, just above freezing temperature, it would always recur about three or four o'clock in the afternoon.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

WATER SUPPLY AND WATER PURIFICATION
A SYMPOSIUM
Discussion*

By Charles Haydock, Assoc. M. Am. Soc. C. E.

Charles Haydock,† Assoc. M. Am. Soc. C. E. (by letter).‡—In the past, the subject of industrial water supply has not received the attention to which it is rightly entitled. During recent years there has been a decided change of opinion coincident with the growing realization of the dependence of many industries on water supply, and the effect that the quality of the water has on the operating costs of such industries. Until comparatively recently only a few industries gave serious consideration to the quality of their water supply, or to the man who, in many instances, realized most forcibly the effect of that quality, namely, the operating engineer whose coal bill was unduly large, whose boiler was pitted unduly, or whose feed-water heaters and hot-water systems were destroyed within a comparatively short time.

Although it is true that the protection of life is the most important function of a water purification plant and, in general, is the fundamental reason for its construction, the chemical effects of the proposed system of purification should be carefully investigated before a decision is made, in order that an unnecessary burden may not be placed on the various industries that will use the purified water. The importance of this feature and the frequency with which it has been disregarded in the older plants can be realized by considering the number of such plants producing an effluent more actively corrosive than the raw water from which it was manufactured. It is also to be noted that the desirable qualities of a water for industrial purposes are not always the same as those for domestic purposes and that the quantities required for the former uses are far greater than for the latter, even in a large city. The use of alum, for instance, increases the hard scale forming qualities of a water when used for boiler purposes.

The methods of reducing the damage caused by industrial water supplies of poor quality should not be made more difficult by ill advised treatment

* Continued from January, 1922, *Proceedings*.

† Engr., Water Companies, Philadelphia, Pa.

‡ Received by the Secretary, January 7th, 1922.

designed to render the water safe for domestic uses. Professor Whipple's statement* that the elimination of the corrosive qualities of water and the purification of water supplies for industrial purposes is a refinement, is unwarranted, and, fortunately, is to-day held by a decreasing number of individuals. Certainly no one connected with the operation of any industry that uses a material quantity of water will agree with such an opinion.

The classification of waters as "active" and "quiet", or more commonly called "passive", as mentioned by Mr. Hazen,† is indeed helpful. In too many cases active waters have been accepted without question, as comparatively few users know that passive waters are obtainable, and, therefore, public sentiment is lacking to compel rendering the waters passive. Active waters constitute a serious handicap to any community required to use them. The corrosive effects in the destruction of service lines, house plumbing, and hot- water piping, are important items of expense in the annual repair bills; after-coagulation is also induced by certain active waters. These effects reduce the capacity of pipe lines to a serious extent, frequently causing the entire stoppage of service lines. In general, the writer believes that it can safely be said that those who are in responsible charge of progressive industrial plants seem to realize the value of soft passive waters to a far greater extent than the designers of many domestic water-treating systems. This has been reflected in the demand for water-treating plants for industries, which, in many instances, use waters already purified for domestic purposes as their raw water supply.

Probably the most dangerous active waters are in the Pittsburgh District.‡ The value of soft quiet water seems to be more clearly recognized there than anywhere else. Few unpolluted streams are available, practically all the larger watercourses carrying large volumes of coal mine drainage, which render them acid continuously or except during the periods of the high spring run-offs. All the major water-using industries in this District find it necessary to maintain water-treating plants which are expensive to operate, but, in some cases, are able to render the waters usable for certain purposes. In the writer's judgment, it can safely be said that from an industrial viewpoint, no treated water is a satisfactory substitute for a naturally pure water supply.

The larger creeks in the Pittsburgh District, in general, are so seriously polluted that no attempt is made to use them. In one instance, a certain creek is used for condensing purposes. The tubes are of acid-resisting bronze and the body is lined with lead and cement. In some instances, in spite of such precautions, these condensers have been destroyed within a period of three months.

The Youghiogheny River flows into the Monongahela a few miles above Pittsburgh and has a drainage area of 1 732 sq. miles. It is acid practically every day in the year, and has reached a maximum of 22 grains per gal. The Monongahela River, the drainage area of which is 7 340 sq. miles, is very hard, but, in general, is alkaline. Its hardness is greatly increased during periods of low flow and, at such times, it frequently becomes acid. This also occurs

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 658.

† *Ibid*, p. 660.

‡ Recently discussed in the *Journal* of the American Water Works Association.

following a rise in the river, due to flushing the upper pools. As a safeguard many of the steel mills which use this water for cooling their rolls, add lime, although, in one instance, the quantity used is approximately 100 000 000 gal. per day.

The supply of the City of Pittsburgh, which is taken from the Allegheny River, is of much better quality, but as long ago as 1912, the Managing Engineer of the Municipal Water-Works called attention to the progressive lowering in the alkalinity of this river and the eventual necessity for taking measures to meet this situation. Since that time there have been no very dry seasons. During the first year in which a protractive deficiency of rainfall occurs, particularly if it should be accompanied by high temperatures, no doubt serious difficulties will be experienced in the operation of the Pittsburgh filter plant.

Although these acid waters are highly active, they are practically never used for industrial purposes without treatment, as they would rapidly destroy boilers and all other metallic structures with which they came in contact. It is interesting to note that, in general, waters which are active, but acid free, do not destroy boilers, as the dissolved gases are eliminated rapidly. If a feed-water heater is used, they are almost certain to be eliminated at that point with a consequent destruction of the heater. As an example, it can be stated that in the office building in Philadelphia in which the writer is located, the hot-water piping was destroyed within a comparatively short time and new piping is now being installed, together with a means of removing dissolved gases, which it is hoped will eliminate the corrosion.

The City of Altoona, in Central Pennsylvania, uses a water supply that is acid at all times. This water is practically impossible of use for industrial purposes without extensive treatment, and it is exceedingly expensive to maintain the house plumbing systems. Meters have recently been installed on all taps, and it will be interesting to note the effect of these acid waters on the meters. It has recently been proposed to attempt to correct this difficulty by carrying the drainage from the coal mines, which contaminates the supply, below the reservoirs by a sewer. As a result of installing meters, the city supply now has a sufficient margin over the demand to permit this to be done, and according to recent newspaper accounts an effort will be made to compel the mine owners to pay for the cost of this work, which was rendered necessary by their mining operations.

Legal actions to protect the purity of a water supply from contamination by coal mine drainage are also in process in Fayette and Westmoreland Counties in Pennsylvania. A water company constructed a storage reservoir and an extensive system of piping. Many years later coal mines were opened above the storage dam. The present litigation has been instituted by the water company and allied interests in an effort to prevent the destruction of its valuable water supply and other properties. This case has been described as the most important pending litigation in Pennsylvania, and its importance is further emphasized by the fact that the Attorney General, acting on behalf of the Commonwealth, has filed petitions for leave to intervene. Argument has been held on these petitions, but so far no decision has been rendered.

The quiet waters between the Alleghanies and Rockies are very hard, and to those accustomed to the softer Eastern waters, almost unbelievably hard. Recently, the engineer of water service of an important Western railroad rather facetiously remarked that some of these waters were so hard that it was customary to analyze them for percentage of moisture rather than for solids.

It is most unfortunate that there is to-day no well established method for treating hard waters satisfactorily. The commoner systems in use simply alter the solids in solution, usually increasing them. Barium is the most common chemical which produces a double precipitation and consequent elimination of the electrolyte, but this treatment is exceedingly costly and the soluble barium salts are poisonous under certain conditions, so that in general this method is not available. If the hardness is high, use of the water for many industrial purposes is prohibitive without some form of softening. This process does not remove difficulties any more than it reduces total solids in solution and, in addition, the use of treated water introduces many problems not encountered in using naturally pure supplies. If the activity of a water is due to acidity, it can be neutralized by the addition of proper chemicals and greatly improved in quality for industrial purposes. This benefit is secured at the expense of an increase in hardness which, at times, may be so great as to be prohibitive, as is the case with so many streams draining the extensively developed coal mining regions.

The legal aspects of stream pollution are of the greatest importance and are now becoming more widely realized. The Legislative Act creating the Pennsylvania Department of Health, of which C. A. Emerson, Jr., M. Am. Soc. C. E., is Chief Engineer, states in part: "This Act shall not apply to waters pumped or flowing from coal mines or tanneries", thereby eliminating the two industries which have caused the most serious pollution of streams in Pennsylvania. The presence of vast areas of high quality coal is beyond question one of the foundations of the industrial supremacy of Pennsylvania, and it is unthinkable that legislation should be enacted, which would seriously handicap this vital industry. On the other hand, there are so few unpolluted streams left in the developed coal regions of Pennsylvania that something must be done unless the future industrial development of the State is to be hampered. This condition has become so serious at times that railroads have been greatly delayed in hauling the coal produced by mines which polluted the streams, the water of which is used for boiler purposes, to such an extent, that all the available locomotives were out of service for repairs.

One of the strongest laws on the statutes of Pennsylvania for the prevention of stream pollution by industries is designed to protect fish, and is administered by the Commissioner of Fisheries. In 1915, in addressing the Pennsylvania Water Works Association, the Commissioner called attention to the difficulties of enforcing this Act by reason of the low penalties provided and the unwillingness of Courts to impose these penalties even in the most flagrant cases where conditions could be remedied with comparatively little difficulty or expense. During the last session of the Legislature, an unsuccessful effort was made to amend this Act and raise the penalties so as

to permit enforcement of the law. As a result, industrial pollution will continue unabated until at least the next session of the Legislature. Practically all forms of industrial pollution of streams destroy the fish life therein, and the effect of this is to render difficult the enforcement of any of the other laws designed to protect the food and game fishes. This condition was particularly apparent during the low water of the summer of 1921, along the Susquehanna River in the vicinity of Williamsport, when large numbers of fish were killed. As a result, the average individual was unable to see why he should be punished for taking a few game fish illegally when industries destroyed many thousand times more fish without incurring any liability. Any law that is not enforced is a menace, in that it leads to disregarding the law in other cases where the effects of such disregard may be even more serious. Another difficulty encountered by the Commissioner in his efforts to prevent pollution is the lack of a suitable means to treat water contaminated by various industries, chiefly coal mining. It was stated that the managers of many industries were willing to install any system of purification satisfactory to the Commissioner, but as no method was then known or has yet been developed, nothing was accomplished, and he did not feel warranted in closing down the industries until a suitable method was developed.

Referring again to the Pittsburgh District, the Youghiogheny River which is uniformly acid, has been devoid of fish life for many years. The Monongahela is said still to contain a few hardy fish which probably live in the vicinity of the mouths of the purer tributaries. The Allegheny is able to support fish life, as is also the Ohio some miles below Pittsburgh, due to the mixing of the Monongahela and Allegheny. A rise in the Monongahela River, unaccompanied by a corresponding rise in the Allegheny, will flush accumulated acid from the pools of the Monongahela and carry it far down the Ohio to points where the waters are ordinarily acid free. The result of this is that large numbers of fish are killed, and the occurrence of this phenomenon has been reported as far as Cincinnati, Ohio.

Several bills designed to prevent the discharge of oil and oil wastes into harbors and navigable streams were considered by the recent special session of Congress. Hearings have been continued and, undoubtedly, similar measures will be introduced into the present session, as some legislation is certainly needed to prevent this serious menace to harbors and beaches. These bills are being opposed by coal operators and manufacturers' associations on the grounds that they might be considered applicable to industrial wastes other than oil sludge. At the latest hearing, held in Washington on December 7th, 1921, Secretary Hoover testified at length on the seriousness of the situation, recommending that at present legislation be passed applicable only to the oil wastes. Conditions with respect to other industrial wastes, he stated, were so different that they should be thoroughly investigated before any action is taken. The difficulties imposed on communities and industries compelled to use the waters polluted by industries were not brought before the Committee. In the writer's judgment, this is a proper field for the Society to enter, and such action is recommended. This could well take the form of a special committee on "Industrial Water Purification and Stream Pollution",

and it does not seem that any further recommendations than Mr. Hoover's remarks should be needed.

Several years ago the U. S. Engineer's Office at Pittsburgh made an extensive investigation of the acidity of the local rivers, and as a result of that investigation a bill was introduced into Congress to prevent the discharge of acid mine wastes into navigable rivers or their tributaries. Such drastic legislation, naturally, did not pass, but it is to be hoped that, in the near future, some provision will be made for the abatement of what was once a nuisance, but what has now become a menace.

The availability of a satisfactory water supply is an important feature in determining the location of large industrial plants, as is indicated by inquiries received at the offices of industrial agents of large railroads. The report of the recently completed Super-Power Survey recommends that generating stations be built adjacent to the coal mines wherever condensing water is available.

In view of the importance of pure water for industrial purposes, and the lack of satisfactory methods of purification, the writer believes that there is need for research to be conducted on a broad scale and pursued to a conclusion, preferably by some such Federal agency as the Bureau of Standards. An investigation of this nature was conducted by the Pennsylvania Department of Health. As no results were announced, it can be assumed that the investigation was unsuccessful. It was indeed most unfortunate that such an important investigation which was being conducted at such a small cost, should be discontinued on the grounds of economy, as such results are a powerful deterrent to any one contemplating work of this nature.

The greater fall in rural typhoid in the original registration area, as mentioned by Professor Winslow,* may have been due to cases carried by media other than water, or to the general rise in the standard of living during recent years.

It has frequently been noticed that typhoid fever in communities served by private water companies is at times charged to the water supply without investigations being made. This has occurred in several instances with which the writer is familiar although analyses showed the public water supply to be satisfactory while analyses of wells and springs used for drinking purposes by many consumers of the water company showed the presence of *B. coli* in very small samples. Fair and impartial judgment would seem to require that all other possible sources of contamination should be investigated, such as milk, ice, ice cream, soda water, raw foods, etc., before the outbreak is charged to the water company.

It is unfortunate that the local physicians do not always aid in quieting the hysteria which so often develops following an outbreak of intestinal disease. Valuable service could be rendered to the communities by calling attention to other sources of possible contamination in cases where the water analyses are satisfactory. In some instances, this, no doubt, would lead to an earlier checking of the spread of the disease.

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 664.

MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Acting Secretary prior to the final publication.

JOHN FINDLEY WALLACE, Past-President, Am. Soc. C. E.*

DIED JULY 3D, 1921.

John Findley Wallace was born at Fall River, Mass., on September 10th, 1852. He was a son of David A. and Martha (Findley) Wallace.

In his early childhood, his father was sent to Monmouth, Ill., for the purpose of founding a college under the auspices of the United Presbyterian Church. Reared under the unusual social conditions formed by that combination of college, religious, and semi-pioneer life, the boy early manifested those manly, studious, and persevering qualities which, coupled with his high character and attractive personality, gave him the commanding position in the Engineering Profession which he so long enjoyed.

A student in Monmouth College until 1871, Mr. Wallace started his engineering career, in his nineteenth year, with the United States Corps of Engineers, and was engaged for five years on improvements of the Rock Island Rapids and the Upper Mississippi River and its tributaries.

For the following three years, he filled the positions of County Surveyor of Warren County, Illinois, and City Engineer of Monmouth, Ill., and, for five years thereafter, he was in charge of the location, construction, and operation of a railroad from Peoria to Keithsburg, Ill., which was afterward merged with the Iowa Central Railroad Company, and now forms part of the Minneapolis and St. Louis Railroad.

From 1883 to 1886, Mr. Wallace was associated with the Iowa Central Railroad Company as Chief Engineer of Construction, during which time he designed and constructed transfer facilities across the Mississippi River at Keithsburg, Ill., for that Company, and was Associate Engineer on the construction of a bridge, and its approaches, crossing the Mississippi River at that point.

From 1887 to 1889, Mr. Wallace was with the Atchison, Topeka and Santa Fé Railway Company, acting as Bridge Engineer on the extension of that Company's line between Chicago, Ill., and Kansas City, Mo., and having charge, as Resident Engineer, of the bridge built by the Company over the Missouri River at Sibley, Mo. During this period, he designed the foundations for the bridge over the Mississippi at Fort Madison, Iowa, and designed and had charge of the rectification works built in connection with the two bridges at Fort Madison and at Sibley.

From 1889 to 1891, Mr. Wallace was associated with the late E. L. Corthell, Past-President, Am. Soc. C. E., Consulting Engineer, in Chicago, and had charge of the construction of a joint entrance into the City of Chicago for the Atchison, Topeka and Santa Fé Railroad Company and a western connection

* Memoir prepared by the following Committee: A. S. Baldwin, F. A. Molitor, E. J. Noonan, and H. R. Safford, Members, Am. Soc. C. E.

for the Illinois Central Railroad Company. He acted as Associate with Mr. Corthell during this time on the foundation work of the Merchants' Bridge over the Mississippi River at St. Louis, Mo., and was likewise associated with him on various other works, including a proposed bridge over the Mississippi River in the vicinity of New Orleans, La.

In 1891, Mr. Wallace was appointed Chief Engineer of the Illinois Central Railroad Company, and immediately rendered distinguished service to that Company in the reconstruction of its terminals within the City of Chicago for the purpose of meeting traffic conditions arising through the location of the World's Fair adjacent to the tracks of the Company. In this connection, he was largely influential in the beginning of track elevation in Chicago, the Illinois Central, through his counsel and advice, being the first railroad company to enter into a contract for track elevation in that city.

During his service as Chief Engineer, the Illinois Central Railroad Company went through a period of great development in both construction and maintenance work; many branches and auxiliary lines were built, on many parts of the line, grades were reduced, alignment was improved, and second track was built. Many large yards were constructed, likewise large terminal facilities in New Orleans, St. Louis, and other places, and the general condition of the road was greatly improved.

In 1898, Mr. Wallace was transferred to the Executive Department, serving with the various titles of Assistant Vice-President, Assistant General Manager, and General Manager, until 1904, when he left the Illinois Central Railroad Company, having been appointed by the late President Roosevelt as Chief Engineer of the Isthmian Canal Commission. Later, he served as a member of that Commission, and was also a member of the Executive Committee and Vice-President and General Manager of the Panama Railroad and Steamship Company.

Mr. Stuyvesant Fish, at that time President of the Illinois Central Railroad Company, said of Mr. Wallace:

"There is no professional engineer I know who has in a higher degree than Mr. Wallace the special commercial and diplomatic tact needed on the new job. He has an excellent and rare capacity for dealing with men, above, beside, or below him, and he will be an honor to the Government and to himself."

There can be no doubt that to Mr. Wallace was largely due the credit for the organization originally built up for the construction of the Panama Canal, his knowledge of railroad transportation, a feature of prime importance, coupled with his wide and varied experience in engineering construction, rendered him peculiarly competent to organize and conduct a work of such great magnitude.

In 1905, Mr. Wallace relinquished his work at Panama and returned to the United States. On account of his reticence, his full reasons for resigning were never made public. It was known, however, that he was not in accord with the policy of the Administration in certain essential features connected with the plans and conduct of the work, notably the determination not to construct a sea-level canal.

In 1906, he acted as Confidential Adviser to the President of the Chicago and North Western Railway Company in the design of its new passenger terminals in Chicago, and very shortly thereafter he went to New York City to become President of Westinghouse, Church, Kerr and Company, at that time one of the largest engineering and construction organizations in the United States. During his association with that organization, it was engaged in the design and construction of engineering works of great magnitude in different parts of the United States and Canada, including the construction of terminal and dock facilities for the Canadian Pacific in various places, as well as work of the same character at different times for the Chicago, Burlington and Quincy, the Central Railroad of New Jersey, the Chicago and Alton, and the Baltimore and Ohio Railroad Companies. In addition to this railroad work, his Company constructed a number of large hotel, office, and factory buildings. During the ten years he directed the activities of this organization, it is estimated that its expenditures averaged over $10 000 000 per year.

In 1913, Mr. Wallace was retained by the City of Chicago in an advisory capacity in connection with the granting of a franchise to the Union Station Company. This led to his permanent employment by the City as Chairman of the Chicago Railway Terminal Commission, a body of distinguished engineers, lawyers, and members of the City Council which was organized to act in an advisory capacity to the City in all matters relating to railroad terminal facilities of magnitude within the city limits.

Mr. Wallace's unusual diplomatic ability, coupled with his experience in engineering and administrative capacities, well fitted him to harmonize the many conflicting interests involved in the great work of putting on a stable basis the relationship between the City of Chicago and the great railroad companies with which it was involved in transactions during this period. To his efforts, in no small measure, must be attributed the satisfactory solution of the Union Station problem and the arrangement made between the City, the South Park Commissioners, and the Illinois Central Railroad Company, culminating in what is known as the "Lake Front Ordinance", covering the extensive improvements required for the construction of a great system of parks on the Lake Front by the South Park Commission; the relinquishment of its riparian rights; the electrification of its lines within the city limits; the building of a great passenger station by the Illinois Central Railroad Company; and the dedication for the benefit of the United States Government of a great harbor district.

In 1914, Mr. Wallace was head of the delegation made up of members of the Chicago Railway Terminal Commission, the Chairman of various Aldermanic Committees, and other prominent citizens, of Chicago, in a visit to Europe for the purpose of investigating terminal facilities of railroads and waterways, and the construction of wharves, harbors, and docks. This investigation was broken up by the sudden declaration of war on the part of Germany.

Since 1915 Mr. Wallace had acted as Consulting Engineer, Director, and Member of the Executive Committee of the Taylor-Wharton Iron and Steel Company. For five years he was a member of the Committee of Harbors and

Shipping of the Chamber of Commerce, State of New York. He had also been Chairman of the Board of Directors of the Southern Oil and Transport Corporation and Chairman of the Board of Directors of the Century Oil Company.

During the World War, Mr. Wallace served as a member of the Transportation Committee of the National Petroleum Advisory Board.

At the time of his death, July 3d, 1921, he was in Washington attending the hearings of the Senate Committee on Interstate Commerce, in connection with the Board of Economics and Engineering which had been formed by the National Association of Railroad Security Holders, of which Board he was a member. The last words of his testimony before the Senate Committee were characteristic in voicing the earnest desire that he and the Board with which he was associated might be helpful in bringing together the various conflicting interests for the betterment of the transportation system.

He was married to Sadie Ulmer, of Monmouth, Ill., who, with a son, Harold Ulmer Wallace, and a daughter, Mrs. Pierre LeMay, survives him.

Mr. Wallace was a member of many social, professional, literary, and public clubs in the cities of New York, Chicago, and Washington, a list of which, together with a list of technical societies of which he was a member and a summary of the degrees that were conferred on him, is here given.

He was a member of the following clubs: (Chicago), Chicago Club, Union League, Engineers' Club, Association of Commerce, City Club, Press Club, and South Shore Country Club; (Washington), Metropolitan, and Cosmos; and (New York City), Union League, Sleepy Hollow Country Club, Engineers' Club, Engineers' Country Club, Bankers Club of America, Chamber of Commerce, Automobile Club of America, National Arts Club, and Railroad Club.

Mr. Wallace was also a Member, and Past-President, of the American Railway Engineering Association; Member, and Past-President, of the Western Society of Engineers, Chicago, Ill.; Member of the Institute of Consulting Engineers of America; and Member of the Institution of Civil Engineers in Great Britain.

Mr. Wallace held the degree of Civil Engineer from the University of Wooster, Ohio; the degree of Doctor of Literary Laws from Monmouth College, Monmouth, Ill.; and the degree of Doctor of Science from Armour Institute, Chicago, Ill.

His activities, as enumerated herein, are far from covering the wide range of service performed in a highly useful, energetic, and technical career of practically fifty years.

To close this brief memoir without some reference to those personal traits and qualities which endeared Mr. Wallace to his friends and distinguished him as a man, would be to give only an inadequate idea indeed of his character. An intimate associate for a number of years has given as his three outstanding characteristics:

First.—His interest in, and helpfulness to, young engineers.

Second.—His wonderful initiative and energy.

Third.—His unblemished character in every phase of his life.

In his treatment of young engineers, while consistently kind and fair, he was exacting, combining kindness with discipline. He demanded a full measure of service.

Mr. Wallace had a quality of cementing friendships to a rare degree. His characteristics in this connection were well illustrated in an address given by him to the graduating class of Monmouth College in 1916 in which he said: "My first advice to you would be to cultivate friends. Begin with your own family circle and let your friendships extend to include your neighbor, your city, your State, your country, and finally broaden it out to include and embrace humanity. Other things being equal, the measure of your success will depend upon your friendships."

The American Railway Engineering Association stands as one of the best monuments to his ability and skill as an organizer, as it was largely to the acumen and diplomacy which he evidenced in co-operating with other members of his Profession in the building up of this organization that its great success has been due, he having been one of the primary leaders in the movement and the first President of the Association. The result of the Association's work is outstanding among the professional societies of the United States. Its *Proceedings* constitute to-day the principal authority on which the present methods of railroad engineering are based. They have been commented on in international circles and, at one period, during the World War, the United States Government ordered 2 500 copies of the "Manual" of the Association for distribution among the officers of the Engineering Corps.

During his residence in Chicago, Mr. Wallace exercised a potent influence on the affairs of the Western Society of Engineers, becoming its President, first in 1891 and again in 1896.

In 1900, the American Society of Civil Engineers was the guest of the Institution of Civil Engineers in Great Britain, holding its Annual Convention that year in the Society House of the Institution in London, at which time Mr. Wallace had the unique distinction of being the President of both the Society and the American Railway Engineering Association, giving the Annual Address of the former at this Convention in the Society House of the Institution.

Mr. Wallace contributed many papers of great value to the *Transactions* of the Society, as well as to the American Railway Engineering Association. He was one of the charter members of the American Institute of Consulting Engineers and was the first Chairman of its Committee on Professional Practice and Ethics, having been practically the author of the Code of Ethics which this Institute adopted.

Future historians of the Profession will class Mr. Wallace among the great engineers of the country. He was a keen student, an able administrator, an accomplished diplomat, and a gentleman of the highest type, and coupled with these qualities was a personality of great attractiveness.

His life will stand as an inspiration to the younger members of the Profession as illustrating the attainment possible through high character, a deep thoughtfulness in professional matters, and a genius for acquiring friends.

Mr. Wallace was elected a Member of the American Society of Civil Engineers on June 2d, 1886. He also served the Society as Vice-President in 1897 and 1898, as President in 1900, and as Treasurer in 1913 and 1914.

GEORGE DUNCAN SNYDER, M. Am. Soc. C. E.*

Died October 21st, 1921.

George Duncan Snyder, the son of George Stephen and Anna Wesley (Butler) Snyder, was born at Williamsport, Pa., on September 25th, 1866, and received his early education in the public and private schools of Pennsylvania.

His American ancestors belong solely to Pennsylvania, having come to that State between 1750 and 1790, and were of English, Irish, Scotch, French, and German extraction. They and their descendants were prominent as soldiers, sailors, engineers, ministers, and public officials.

From 1882 to 1886, Mr. Snyder was engaged in the office of his uncle, Antes Snyder, at that time Engineer of Right of Way of the Pennsylvania Railroad, and was employed on re-surveys of right of way, in addition to railroad location and construction, for that Company.

Later, he went West, on the lines of the Union Pacific Railroad, and during 1886-87 was engaged on branch line construction. He returned to the East, however, in the latter part of 1887, and from that time until 1890, was Assistant Supervisor on Maintenance of Way of the Pennsylvania Railroad.

From 1890 to 1893, he transferred his affiliations to the Philadelphia and Reading Railroad, becoming Assistant Engineer on the Williamsport Division. He was engaged in the re-alignment of the railroad of that Company, as well as in the layout of coal storage yards and the location of branches and connecting lines. During this period Mr. Synder had full charge of the preliminary and location surveys of the Southern Central Railroad along the west side of the Susquehanna River, from opposite Sunbury to near Harrisburg, Pa.

During 1893, he still further transferred his allegiance to the Erie Railroad, having been engaged in the New York Office of the late C. W. Buchholz, M. Am. Soc. C. E., on studies for and renewals of the structures of that Company.

In 1894, Mr. Snyder was appointed to the office of City Engineer by the authorities of his home town, Williamsport, which office he ably filled for a period of seven years, during which time he was responsible for the construction of the storm and drainage sewer system. During this period of service, he acted as a member of a Board of Engineers, with the late C. W. Raymond, M. Am. Soc. C. E., then Major of Engineers, U. S. A., and, later, Brigadier-General, U. S. A., and the late L. Y. Schermerhorn, M. Am. Soc C. E., in making a report on the protection of the City of Williamsport from floods of the Susquehanna River.

* Memoir prepared by J. V. Davies, M. Am. Soc. C. E.

In 1902, Mr. Snyder joined the staff of Jacobs and Davies, Consulting Engineers, and was engaged to proceed to Burma, India, where, for about a year, he carried out surveys and made a report and estimates for an oil pipe line of about 360 miles for the Burmah Oil Company, extending from the refineries at Rangoon up the Valley of the Irrawaddy River to the oil fields at Yenang-Yat. After his return from Burma, he was further associated with the purchase and inspection of material for this pipe line which was constructed on the lines of the surveys made by him.

On the conclusion of this work, the construction of the underground railroad system of the Hudson and Manhattan Railroad was in active progress, and Mr. Snyder was transferred to the staff of the Hudson Companies as Principal Assistant Engineer on that work. With the work of construction of this underground railroad, he maintained connection to the time of the delivery of the railroad to the operating company, and, thereafter, as Deputy Chief Engineer of the Hudson and Manhattan Railroad Company. During this period of about 13 years, he was engaged for the most part on, and had charge and direction of, design and methods of construction, in which work he showed marked ability and originality.

Except for intervals when absence on military service took him away from his engineering work, he continued his connection with Jacobs and Davies to the time (January, 1921) when his illness necessitated his retirement from active business. From 1913, until the time of his retirement, he was a Director, and, from 1917, Vice-President, in the organization of Jacobs and Davies, Incorporated.

In his engineering work, he was always a deep and well-read student of the principles and practice of engineering, and constituted in himself a vast fund of information in all lines of professional work. In a professional capacity, he took an active part in the development of the city subway system of the New York Municipal Railway Corporation and made a special study of the subject of city transportation. He received the "George Stephenson Gold Medal" from the Institution of Civil Engineers (London) in 1913, for his paper entitled "City Passenger Transportation in the United States." He also contributed to the Society, in 1914, a paper on "Subaqueous Highway Tunnels."* If a single expression could be used which would best describe his personal character, that word would be "faithful."

Col. Snyder was, at all times, deeply interested in military affairs and for a great many years devoted a large part of his spare time to the study of military science and practice. As a young man, he served in all ranks, from private to Captain, in the National Guard of Pennsylvania. When the United States declared war with Spain, he took a commission with the 12th Pennsylvania Volunteer Infantry, and during part of that campaign, he was Assistant Chief Engineer of the 2d Army Corps. When the World War broke out in 1914, he became deeply interested in what he believed to be the inevitable participation by the United States in the war. On November 19th, 1915, he read a short paper before the New York Railroad Club on the subject of "The Railroads and National Defense", which he considered of vital importance to

* *Transactions*, Am. Soc. C. E., Vol. LXXVIII (1915), p. 252.

the prosecution of a successful war. He took a great deal of personal interest in this subject, to the extent of obtaining the co-operation of Gen. Leonard Wood, U. S. A., and other prominent military men who discussed the paper and urged on the people the necessity of building up the strength of the National Guard regiments in anticipation of probable interference. The result of his activity in this line was that he was offered a commission in the 22d Regiment, N. G. N. Y., and although he had no desire to go back into the National Guard, he felt that his duty called him to the colors and to a participation in the activities which had arisen due to the war. The Mexican Border troubles of 1916 involved the call of this regiment into active service, and he proceeded, as Lieutenant, to the Mexican Border, serving there from June, 1916, to January, 1917, receiving a commission as Captain while on the Border.

As soon as the United States entered the World War in 1917, he volunteered for active service with the 22d Engineers and assisted in organizing the 102d U. S. Engineers, answering the President's call on July 15th, 1917. He was drafted into Federal Service on August 5th, 1917, and sailed for overseas duty in May, 1918. He served with 27th Division, A. E. F., and was on duty with the American Commission to Negotiate Peace, in January and February, 1919, in France and Italy. He returned to the United States as Major, U. S. Engineers, and was honorably discharged in April, 1919. Thereafter, he became Major, Engineer Section, Officers Reserve Corps. In the re-organization of the 22d Engineer Regiment, N. G. N. Y., he took an active part as Lieutenant-Colonel, under Col. Thomas Crimmins, on whose retirement in April, 1920, he became Colonel of the regiment. This commission he took with the expressed understanding that he could retire as soon as the regiment was completely Federalized. This he carried out, retiring from the command in October, 1920, when, at his own request, he was transferred to the reserve List, N. G. N. Y.

His service in the Army, and the regard in which he was held by his fellow officers and men, is particularly well stated in the following letter of Col. Crimmins:

"* * * I want to write you a few lines about my thoughts of George Snyder. I want you to consider them as coming from one who served under and with him. It was only for a brief period that I served as his Colonel. I started in the regiment looking up to George, and I finished that way.

"From February, 1916, when I enlisted in Company G, 22d Regt., N. G. N. Y., under Lieut. George D. Snyder, until April, 1920, when I retired as Colonel of the regiment, I was very closely identified with George Snyder. I observed him as an enlisted man and as an officer. Of George Snyder, I have often said that I never knew a better engineer soldier. Intelligent and studious, he mastered all problems that came before him. Brave and self-sacrificing, he carried out all orders given him, shunning no responsibilities, loyal and conscientious in all his acts he gave all he had to his country.

"George Snyder will always live in the hearts and minds of all who served with him in the war."

Col. Snyder also served, after his discharge from the Army, as Secretary of the Military Affairs Committee of Engineering Council.

His last illness was long and protracted and probably originated in his overseas service in the Army, during which time he suffered from shell shock and gas. He passed away at the home of his sister, at Jersey Shore, Pa., on October 21st, 1921.

Col. Snyder was married in 1901 to Miriam Ellen Harrison, of Williamsport, and is survived by three children.

He was a member of many professional and patriotic societies, including the Institution of Civil Engineers, American Railway Engineering Association, American Institute of Consulting Engineers, Sons of the Revolution, and Society of the War of 1812.

Col. Snyder was elected an Associate Member of the American Society of Civil Engineers on November 6th, 1895, and a Member on September 4th, 1901.

GEORGE HERBERT WEBB, M. Am. Soc. C. E.*

Died November 3d, 1921.

George Herbert Webb, the son of Col. George Webb and Emma (Alder) Webb, was born in Dubuque, Iowa, on March 5th, 1860. Both his father and mother came from Muncy, Pa., where his grandfather had acquired a considerable estate in the early part of the Nineteenth Century. In 1850, his father went West, but after the Civil War he returned to the East and was prominently indentified with the construction and operation of various railroads, and with the steel industry. The family made their home in Williamsport, Pa., and, in 1876, moved to Johnstown, Pa.

Mr. Webb was educated at the Pennsylvania Military College, at Chester, Pa. He entered the Sophomore Class in Engineering in September, 1877, and was graduated from this institution, then known as the Pennsylvania Military Academy, as a Civil Engineer with the degree of C. E., on June 10th, 1880.

After his graduation, Mr. Webb entered railroad work as Rodman with the Baltimore and Ohio Railroad. In 1881, he tested steel for the Brooklyn Bridge, and, in 1883, was appointed City Engineer of Johnstown, Pa. Later, he was Assistant Engineer of the Cambria Iron and Steel Company.

From the fall of 1885 to the spring of 1888, Mr. Webb was with the Chicago, Burlington and Quincy Railroad as Transitman, Locating Engineer, and Division Engineer on construction, and, in 1888, served as Division Engineer in charge of the construction of portions of the Seattle, Lake Shore and Eastern Railroad (now a part of the Northern Pacific System).

In the spring of 1899, he went to Chile, with the North and South American Construction Company. This Company had a contract with the Chilean Government for building and equipping between 600 and 700 miles of railroad, and Mr. Webb was in charge of the construction of one of the branch lines in the southern part of the Republic. The entire work was stopped later by the outbreak of the Balmaceda Revolution.

On leaving Chile, he went to Peru and, in 1891, was appointed Division Engineer and Superintendent of Construction of the Summit Division of

* Memoir prepared by William H. Sellew, Esq., Ann Arbor, Mich.

the Central Railway of Peru, formerly the Aroya Railroad. The construction of this Division was a notable piece of work. The line crosses the main range of the Cordilleras de los Andes 15 657 ft. above sea level, and has heavy grades, high curvature and many tunnels.

In 1893, Mr. Webb returned to the United States and engaged in private engineering practice until 1897, when he was appointed Chief Engineer of the Cincinnati, Georgetown, and Portsmouth Railroad. This road was a small property in charge of Mr. Ralph Peters, and although his associations were pleasant, Mr. Webb wished to study maintenance on larger roads and at the end of two years resigned his position to enter the service of the Cleveland, Cincinnati, Chicago and St. Louis Railway.

During 1899 and 1900, he was Supervisor of Track on the latter road and on the Chicago and Alton Railroad, and, in 1901 and 1902, Engineer in Charge of Construction of the Missouri Pacific Shops at Baring Cross, Ark.

Mr. Webb entered the service of the Michigan Central Railroad in 1903 and had charge of relocating the main line between Kalamazoo and Lawton, Mich., a work of some magnitude. He was promoted successively to be Division Engineer, Assistant Chief Engineer, and, in 1905, was appointed Chief Engineer. He occupied the latter position until his death with the exception of about two years, from 1917 to 1919, when he was in military service in France.

The Detroit Terminal of the Michigan Central Railroad is probably the most prominent monument to Mr. Webb's engineering ability. It may be included with such structures as the Grand Central and the Pennsylvania Terminals, in New York City, and the Kansas City Union Depot, as among the four or five largest projects of this character which have been completed within the last decade.

Mr. Webb served in various important military positions in the American Army during the World War, attaining the rank of Colonel. He was awarded the Distinguished Service Medal,* and also the French Ordre de l'Etoile Noire (Officier) by Presidential decree of September 24th, 1919.

On July 6th, 1917, he was appointed Lieutenant Colonel in the Sixteenth (Railway) Engineers. The regiment landed in France on August 29th of that year and took charge of the construction of the Advance Depot at Is-sur-Tille.

About April 1st, 1918, Col. Webb was placed in charge of a number of railway and camp projects in the vicinity of Nevers. This position soon developed into that of Section Engineer of the eastern half of the Intermediate Section. In this capacity, Col. Webb had charge of the American engineering projects in about one-seventh of the area of France, extending from the City of Bourges to the Swiss and Italian borders. Among the projects carried on under his direction were the large hospital plants at Mesves-Bulcy, Mars-sur-Allier, and Allerey, with a combined maximum capacity of 72 000 patients.

The Nevers Cut-Off, from an engineering point of view, was the most difficult railway construction by the American Expeditionary Forces. It required a large yardage of embankment and the construction of a pile and

* General Orders No. 59, War Department, Washington, 1919, p. 33.

steel truss bridge over the Loire River, 2 200 ft. long. Other railway projects were the engine terminal at Marcy, and the car repair shops at Nevers. Warehouses, camps, camp hospitals, and laundries, were constructed and reorganized at various centers, and at Vichy, Clermont-Ferrand, Chatel Guyon, Royat, and Pougues-les-Eaux, groups of resort hotels were taken over and adapted to hospital purposes. At the center at Vichy alone more than 75 000 patients were treated.

All this work was carried on subject to continuous wartime interference with the supply of men, materials, equipment, and transportation. Col. Webb's inspiring and driving personality stirred the officers and men in the organizations under him, and by his resourcefulness, initiative, and skill, he overcame all obstacles and completed these difficult projects with marked success.

On September 27th, 1918, he was promoted to the rank of Colonel and in April, 1919, returned to the United States and resumed his duties as Chief Engineer of the Michigan Central Railroad.

In the fall of 1920, Colonel Webb's health showed signs of failing, and in the following spring an operation was performed without, however, obtaining the hoped for relief. He died on November 3d, 1921, at the home of his sister, Mrs. G. L. Osgood, Jr., near Boston, Mass.

Col. Webb was a man of strong personality and sterling qualities. He was a thorough student and possessed keen insight, and his work showed in a high degree evidence of original and self-reliant thought. His interesting experiences and unusual personal charm made him a delightful companion, and his death will be long felt by the many who had the privilege of knowing him.

In January, 1905, he was married to Jessie Lawrence, who died in May, 1907. They had many congenial tastes, and his home life afforded pleasant relief from the close application he was in the habit of giving to the duties of his profession. Her untimely death was much to be regretted.

On June 17th, 1914, the Board of Trustees of the Pennsylvania Military College conferred on Col. Webb the honorary degree of Master of Civil Engineering, in recognition of his high professional attainments and his worthfulness as a man and citizen.

He was a member of the American Railway Engineering Association, and served the Association as Director and Chairman of the Committee on Rules and Organization. He was the first Commander of the Detroit Chapter of the Military Order of the World War, a member of the Sixteenth Engineers Post Veterans of Foreign Wars of the United States, and of the American Legion.

Colonel Webb was elected a Member of the American Society of Civil Engineers on February 1st, 1893.

HAROLD INGERSOLL BELL, Assoc. M. Am. Soc. C. E.*

Died December 28th, 1921.

Harold Ingersoll Bell was born at Canton, Ill., on August 16th, 1880. He prepared for college at the Bay City, Mich., High School. After one year at

* Memoir prepared by Henry S. Huntington, Esq., New York City.

the University of Michigan, he entered Cornell University in 1901, from which he was graduated in Civil Engineering.

Since 1906, Mr. Bell had been associated with the H. P. Cummings Construction Company of Ware, Mass. In 1912, he was made Manager of the Portland Office of the Company, which was opened that year, which position he held until his death.

In this capacity, Mr. Bell had charge of the construction of a number of large plants in the State of Maine, the best known of which was the Hydro-Electric Development of the Rumford Falls Power Company, at Rumford, Me.

On April 27th, 1916, he was married to Ellen Morrell Foster, daughter of Mr. and Mrs. T. D. Foster, of Ottumwa, Iowa, who, with two sons, Hugh Foster and Gordon Humphrey, survive him. He is also survived by his mother, Mrs. Mary E. Bell of Ithaca, N. Y., and two sisters.

Mr. Bell was elected an Associate Member of the American Society of Civil Engineers on August 31st, 1915.

HENRY HARVIE, Assoc. M. Am. Soc. C. E.*

Died October 14th, 1921.

Henry Harvie was born near Birmingham, England, on October 4th, 1873. He received his technical education at University College, London. On the completion of his studies in 1896, he entered the service of the Great Western Railway Company as an Assistant Chief Draftsman at the Swindon Works, where he remained until 1903. Mr. Harvie's ability as a Draftsman and Designer was recognized among those who knew him as being of the highest quality, combining the artistic with the technical to a remarkable degree.

In 1903, Mr. Harvie came to Canada, and joined the Engineering Staff of the Ontario Power Company, at Niagara Falls, Ont., Canada. In 1905, he joined the Designing Department of the J. G. White Engineering Corporation of New York City. He resigned in 1906, to accept the position of Chief Draftsman for the Bush Terminal Company, Brooklyn, N. Y., and, later, was appointed Chief Draftsman of the Long Island Motor Parkway.

From 1908 to 1910, Mr. Harvie was again with the Ontario Power Company as Chief Draftsman, during the extensive additions which were then being made to its plant at Niagara Falls. At that time, this plant was numbered among the largest developments of the world, and the great difficulties to be overcome in both design and construction required engineering talent of the highest quality. In 1910, Mr. Harvie was appointed Assistant to the Chief Engineer of the Lake Superior Power Company, in charge of the design of a hydro-electric power development on the Magpie River in the Michipicoten District, north of Lake Superior, for supplying power to the mines operated by the Algoma Steel Company. On the completion of this work, he joined the Engineering Staff of the Hydro-Electric Power Commis-

* Memoir prepared by G. R. Heckle, M. Am. Soc. C. E.

sion of Ontario, at Toronto, where he was for the most part employed as Chief Draftsman on hydro-electric power plant design.

Latterly, Mr. Harvie was employed by C. H. and P. H. Mitchell, Consulting Engineers, of Toronto. The unfortunate accident which caused his death on October 14th, 1921, took place in the plant of the General Electric Company, at Peterborough, Ont., while he was inspecting a shop test of a generator rotor.

He was married in England to Miss Dora Gaskell who, with three children, survives him.

Mr. Harvie had acquired a broad experience and training, particularly in the hydro-electric field, and had become recognized as an authority on the various features of power-plant layout and design. This, coupled with his natural ability as an engineer, had placed him high in the ranks of his Profession.

He became an Associate Member of the Canadian Society of Civil Engineers in 1912, and for some time was a member of the Engineers' Club of Toronto, where he had a large circle of friends.

Mr. Harvie was elected an Associate Member of the American Society of Civil Engineers on May 12th, 1919.

HARRY MILTON LYNDE, Assoc. M. Am. Soc. C. E.*

Died May 17th, 1921.

Harry Milton Lynde, the son of James, Jr., and Lizzie Estelle (Clifford) Lynde, was born in Chelsea, Mass., on December 27th, 1882. He was educated at the Massachusetts Institute of Technology, having been a member of the Class of 1905, and at the Polytechnic Institute of Brooklyn, from which he was graduated in 1906, receiving the degree of C. E.

During the summer vacation in 1903 and 1904, Mr. Lynde was employed as Rodman by the Metropolitan Park Commission of New York, and the summer of 1905 was spent as Rodman on the Boston and Maine Railroad.

The greater part of the next two years were spent by him in gathering and compiling data for the National Board of Fire Underwriters and Fire Insurance Companies.

In October, 1907, Mr. Lynde was appointed Assistant Drainage Engineer, Office of Experiment Stations, U. S. Department of Agriculture, which position he retained until May, 1909. During this time, he was engaged principally on drainage surveys and investigations in the Southern States.

From May, 1909, to January, 1913, he served as Assistant Engineer to the New York Board of Water Supply engaged in the construction of the Catskill Aqueduct.

In January, 1913, Mr. Lynde returned to the office of Experiment Stations, U. S. Department of Agriculture, and took charge of the drainage work of the office in North Carolina, which position he held until his death at Raleigh, N. C., on May 17th, 1921.

* Memoir prepared by S. H. McCrory, M. Am. Soc. C. E., and Clifford Lynde, Assoc. M. Am. Soc. C. E.

His most important work while in this position was the planning and conducting of investigations relating to the drainage of agricultural lands. His investigations in regard to the effect of tile drains on the ground-water table, which he discussed in a paper read before the Southern Section of the American Society of Agricultural Engineers, at Lexington, Ky., a short time before his death, was a valuable contribution to agricultural science. During this period, he devoted a considerable part of his time to the study of methods of prevention and control of soil erosion, and many examples of his skill in this work are to be found in North Carolina. In 1915 and 1916, he demonstrated the use of terraces for controlling soil erosion in Missouri, and so successful was his work that a general interest in improvements of this character was aroused.

Mr. Lynde was always a student and had a gift for research. His character was of the finest, and his dealings were always characterized by fine courtesy and integrity.

On June 28th, 1911, Mr. Lynde was married to Amy Louise Edmester, of Massachusetts, who, with a daughter, Marguerite, survives him.

He was a member of the American Society of Agricultural Engineers and the American Association of Engineers.

Mr. Lynde was elected a Junior of the American Society of Civil Engineers, on April 14th, 1911, and Associate Member on April 1st, 1914.

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"RAILROAD TRANSPORTATION": A Symposium.

"HIGHWAY TRANSPORTATION": A Symposium.

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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

VOL. XLVIII—No. 3

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

March, 1922

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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XLVIII—No. 3.

MARCH, 1922

Edited by the Secretary, under the direction of the Committee on Publications.

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NEW YORK 1922

American Society of Civil Engineers

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President, JOHN R. FREEMAN

Vice-Presidents

Term expires January, 1923:	*Term expires January, 1924:*
EDWARD E. WALL	C. E. GRUNSKY
ANDREW M. HUNT	ROBERT RIDGWAY

Acting Secretary, ELBERT M. CHANDLER

Treasurer, OTIS E. HOVEY

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Term expires January, 1923:	*Term expires January, 1924:*	*Term expires January, 1925:*
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The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

HEADQUARTERS OF THE SOCIETY—33 WEST THIRTY-NINTH STREET, NEW YORK.

TELEPHONE NUMBER........................7100 Longacre.
CABLE ADDRESS.........................."Ceas, New York."

Vol. XLVIII. MARCH, 1922. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

SOCIETY AFFAIRS

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MINUTES OF MEETINGS

OF THE SOCIETY

March 1st, 1922.—The meeting was called to order at 8.15 P. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, 76 members and guests.

The minutes of the Annual Meeting, January 18th, 1922, and of the meeting of February 1st, 1922, were approved as printed in *Proceedings* for February, 1922.

The Acting Secretary announced that the Annual Convention would be held at the Hotel Wentworth, Portsmouth, N. H., on June 21st and 22d, 1922.

The Acting Secretary announced the following deaths:

CHARLES LE ROY ANNAN, of St. Paul, Minn., elected Member, July 4th, 1888; date of death unknown.

FRANK HUDSON CLEMENT, of Philadelphia, Pa., elected Member, November 1st, 1882; died February 18th, 1922.

CYRUS GILDERSLEEVE FORCE, of Ledgewood, N. J., elected Member, February 6th, 1878; died February 7th, 1922.

WILLIAM FESSENDEN MERRILL, of Plainfield, N. J., elected Member, April 1st, 1874; died February 3d, 1922.

KARL DEWITT SCHWENDENER, of Los Angeles, Cal., elected Member, November 25th, 1919; died January 23d, 1922.

ROBERT BREWSTER STANTON, of New Canaan, Conn., elected Member, September 1st, 1880; died February 23d, 1922.

JOHN ALEXANDER DAILEY, of East Orange, N. J., elected Affiliate, September 7th, 1904; died February 9th, 1922.

A paper by G. F. Stickney, M. Am. Soc. C. E., entitled, "Siphon Spillways", was presented by the author, who illustrated his remarks with lantern slides. The subject was discussed by Messrs. Edward Wegmann, who also illustrated his remarks with lantern slides, William P. Creager, H. F. Dunham, and Thaddeus Merriman.

The following report of the Tellers appointed to canvass the ballots for the proposed amendments to the Constitution* was presented by the Chairman, Thaddeus Merriman, M. Am. Soc. C. E.:

"33 WEST 39TH STREET, NEW YORK, N. Y.
"MARCH 1ST, 1922.

"TO THE AMERICAN SOCIETY OF CIVIL ENGINEERS:

"The Tellers appointed to canvass the ballots on the Proposed Amendments to the Constitution report as follows:

"Total number of ballots received		1711
"Deduct		
"Ballots from members in arrears of dues	10	
"Ballots with lettered instead of written signatures	3	
"Ballots unsigned	7	
"Ballots defective	2	
"Total number not entitled to vote		22
"Ballots canvassed		1689

"GROUP I

	Yes.	No.	Necessary to adopt.
"Shall the Amendment to Article II (Marked "A") be adopted?	1606	83	1126
"Shall the Amendment to Article IV (Marked "B") be adopted?	1617	71	1125
"Shall the Amendment to Article VII (Marked "C") be adopted?	1561	121	1121

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 944.

"GROUP II

"Shall the Amendment to Article VII (Marked 1) be adopted?	559	1108	1111
"Shall the Amendment to Article VIII (Marked 2) be adopted?	574	1094	1112
"Shall the Amendment to Article IX (Marked 3) be adopted?	598	1069	1111

"THADDEUS MERRIMAN, *Chairman*,
"C. E. BEAM, "H. C. PADDOCK,
"WILLARD T. CHEVALIER, "FRANCIS W. PERRY,
"RALPH E. DRAKE, "D. H. SAWYER,
"J. H. GRANBERY, "G. L. SAWYER,
"H. C. HUTCHINS, "E. J. SQUIRE,
"L. A. JENNY, "G. EDWARD TILT,
"Tellers."

Adjourned.

OF THE BOARD OF DIRECTION

(Abstract)

January 16th, 1922.—The Board met at 10 A. M., at the Headquarters of the Society; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Alvord, Anderson, Beahan, Brown, Clark, Cummings, Curtis, Darrow, Davis, Elwell, Greene, Grunsky, Henny, Herschel, Hogan, Hovey, Hoyt, Hudson, Humphrey, Langthorn (came in at 10:45 A. M.), Marston, O'Connor, Pegram (came in at 10:20 A. M.), Stuart (came in at 10:25 A. M.), Talbot, and Wall.

The minutes of the meetings of the Board of Direction held October 10th, 11th and 12th, and November 21st, 1921, were approved, with the following corrections to the October minutes:

At the suggestion of the Acting Secretary, that part of the minutes referring to the discussion concerning the Committee of the Board on the Status of the Civil Engineer in Government Work and His Compensation, was changed to read as follows:

"Director Hoyt moved that the Committee be continued as a committee of the Board to gather evidence and make recommendations as to what further action should be taken in connection with the whole question of the status of the Civil Engineer in Government work and his compensation.

"This motion was seconded by Past-President Herschel. Directors Henny and Humphrey discussed it, after which it was carried.

"Vice-President Hunt stated that it would be impossible for him to continue his membership on such Committee, and after general discussion participated in by Messrs. Grunsky, Hoyt, and Pegram, it was agreed that the President was authorized to fill any vacancies that might develop on this Committee."

At the suggestion of Past-President Talbot, that part of the minutes referring to the appointment of Messrs. R. C. Wynne-Roberts and H. E. Riggs, was changed by the addition of the phrase "for the year 1921" after their names.

Vice-President Cummings called attention to the statement in the minutes of the meeting of the Board of October 10th, 1921: "That it is the sense of

this meeting that the Board is not *a priori* opposed to the insertion of advertising in *Proceedings* * * *", which was unanimously adopted, stating that he wished to be recorded as being opposed to advertising in the publications of the Society, and, therefore, does not want to be recorded as voting in favor.

The following minutes of the meetings of the Executive Committee held October 24th, November 21st, December 6th, and December 20th, 1921, were approved, and the actions therein described were made the actions of the Board of Direction:

MINUTES OF MEETING OF EXECUTIVE COMMITTEE, OCTOBER 24TH, 1921.

"The Executive Committee met at 2.30 P. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Herschel, Hovey, Hunt, and Stuart.

"The October Board meeting granted plenary power to this Committee to act in co-operation with the Acting Secretary in all matters involving the operation of the revised Constitution and proposed amendments thereto, including authority to engage Counsel.

"The following three amendments to the revised Constitution were presented by the Acting Secretary, who reported that they had been approved by Society's Counsel, Parker and Aaron (authority to secure such advice having previously been granted individually by members of the Committee):

"'Article II.—Membership. Add Section below, and renumber present Section 9 Section 10':

"'9.—The membership status of members of the Society in any grade, as it was immediately prior to November fifth, 1921, shall not be affected by amendments to the Constitution taking effect on that date, except that the Associates at that time shall thereafter be termed Affiliates.'

"'Article IV.—Dues. Amend Section 3 by inserting after the first paragraph the following:

"'Members residing outside of North America shall pay annual dues as follows: by Corporate Members, twenty dollars; Affiliates, fifteen dollars; Juniors, ten dollars.'

"'Article VII.—Nomination and Election of Officers.

"'Amend Section 4 by inserting in 15th line before the words "No Vote", "In the first and second canvasses for Official Nominees", making the sentence read':

"'In the first and second canvasses for Official Nominees no vote of a Corporate Member for a nominee for Vice-President resident outside of the zone in which the voter resides, shall be counted; no vote of a Corporate Member for a nominee for Director resident outside of the district in which the voter resides, shall be counted.'

"On motion of Vice-President Hunt, seconded by Vice-President Stuart, and carried unanimously, these proposed amendments were approved with the understanding that an effort would be made to secure the signatures of all Directors to these amendments (those present having signed such amendments) and of all the members of the former Committee on Referred Amendments which drafted the revised Constitution.

"Questions in regard to the operation of the new Constitution were presented by the Acting Secretary for an authoritative interpretation, as follows:

"(1) Whether the name of O. E. Hovey, nominee for Treasurer should be issued on the Ballot for Officers to be canvassed at the 1922 Annual Meeting. The new Constitution, effective November 5th, 1921, provides (Article V, Section 2) that the Treasurer shall be appointed by the Board of Direction.

Article VII (Transitory), of the By-Laws, appears to provide that his name shall go out on the Ballot for Officers.

"The following opinion from Parker and Aaron, given under date of October 19th, 1921, in regard to this matter, was reported:

" 'The difficulty arising in this case is due to the fact that among the nominations made by the Nominating Committee under the provisions of Section 2 of Article VII of the Constitution prior to the amendment is contained the name of a nominee for an office which is not to be filled by election at the January, 1922, meeting.'

" 'Our interpretation of the requirement of Article VII (Transitory) of the By-Laws is that the ballots sent out by the Secretary shall contain the names of the persons nominated by the Nominating Committee in so far as they are candidates for offices to be filled at the January, 1922, election. It would be an idle ceremony to send out names of nominees for an office which is not to be filled by election at that time. We do not read the provisions of Article VII of the By-Laws (Transitory) as making any provision for the election of the Treasurer at the 1922 meeting, but only as providing a method for placing before the meeting the nominations made by the Nominating Committee for the officers to be elected at that time. It would, therefore, be our opinion that it would not be proper for the Secretary to include in the form of ballot to be sent out to the Corporate Members any nominations for Treasurer.' "

"On motion of Vice-President Hunt, seconded by Past-President Herschel, and duly carried, it was decided to obtain the advice of Counsel on the question as to whether Treasurer Hovey would be a member of the Board of Direction after the Annual Meeting until his successor had been elected, and the understanding was that his name was not to be issued on the Ballot for Officers to be elected at the 1922 Annual Meeting.

"(2) Whether President George S. Webster will be a member of the Board of Direction for 5 years more, or for 2 years more, after the expiration of his term as President at the 1922 Annual Meeting?

"The following opinion from Parker and Aaron, given under date of October 22d, 1921, in regard to this matter, was reported:

" 'We have your favor of October 21st in which you ask our opinion as to whether the present President, elected under the Constitution now in force, will, at the expiration of his term as President, have a term as Director lasting as long as he shall be one of the five latest living Past-Presidents, or whether his term will last only so long as he shall be one of the two living latest Past-Presidents.'

" 'While the matter is not free from doubt and we express our opinion as follows with some diffidence, it seems to us that the statutory provision with respect to by-laws, to wit, that such a by-law shall not "change the term of office of any Director then in office" and the further provision of the statute concerning changes in the number of Directors, that despite the change effected in the statutory manner "each Director then in office shall serve until his term expires" relate to the specific status and term of a Director then in office as such, and not to a rule of succession in office. In other words, the statute applies to a Director then in office and not to the right of another officer subsequently to become a Director and assume the office.'

" 'Under the existing Constitution of the American Society of Civil Engineers, the President holds an office as President and for the term of one year. As such President he is *ex-officio* a member of the Board of Direction. He is entitled, upon the expiration of his term as President, to hold another office, to wit, that of Director in the Society for a further period, but he is not in office at the present time as such Director. If we may compare the situation to that of a vested interest in real property at the present time, we might say

that the President had a vested right to come into possession of a certain office upon the termination of the term of a present incumbent of that office, just as a remainderman after a life tenancy is vested with a right of ownership upon the death of the life tenant. That right, however, is not at the present time a possession of the land, and so in the case of the officer, it is not a possession or occupancy of the office to which he is at present entitled to succeed. The incumbent of that office at the present time is one of the five living latest Past-Presidents, and it will not be until the term of one of these latest living Past-Presidents expires that there will be an office of Director to be filled by the present President.'

" 'That office is a different one from the office now held by the President, and is not a continuance of his office. In fact, it theoretically may be said that it is uncertain which of the five living latest Past-Presidents will vacate the office of Director. We, therefore, reach the conclusion that the next Director to take office by virtue of the Constitution making a Past-President a Director of the Corporation will take for the term provided in the revised Constitution and not under that in force at the time he was elected to the office of President.' "

"No action.

"The Acting Secretary here also reported the opinion of Parker and Aaron, under date of October 22d, 1921, as follows:

" 'We take this opportunity to remind you of the fact, which has heretofore been brought by us to the attention of officers of the Society, that the mere adoption of the amendment to the Constitution is not of itself sufficient to change the legal number of Directors of the Corporation. The method of changing the number of Directors of a Membership Corporation is prescribed by the statute as follows:

" 'Changing number of directors.—A membership corporation, created under or by a general or special law, may by vote of the majority of its members present at an annual meeting, or at any special meeting duly called for that purpose and so specified in the notice of the said meeting, determine to change the number of its directors to any number which a corporation created under this chapter for the same purposes is authorized to have. Notice of such special meeting shall be given as provided by section twenty-six of the stock corporation law, or by publication thereof once in each week, for three successive weeks next preceding the time when such special meeting is to be held, in at least two newspapers within the county where such special meeting is to be held. On such determination, a majority of the directors shall sign, acknowledge and file an amended certificate specifying such reduction or increase; and thereupon the number of directors shall be the number stated in such certificate. Each director then in office shall serve until his term expires, and there shall be no election of directors, until the number of directors is less than the number specified in the certificate.'

" 'It will be necessary therefore for a motion or resolution to be presented at the Annual Meeting, by which the meeting shall determine to change the number of Directors to that provided in the revised Constitution. As we read the statute, no special notice of this motion is required in the case of the Annual Meeting, and it may be brought up under the order of new business at that time. It would be safer, however, to have such a resolution passed before the formal election of new officers and directors.' "

"Subsequently, the following letter was received from Parker and Aaron concerning this:

" 'In our letter to you of October 22d, calling attention to the requirement that the change in the number of Directors must be effected by a vote of the Annual Meeting, we quoted the statute applicable thereto, but through oversight failed to state that the Legislature this year amended the provisions of the

statute quoted so that the certificate to be made, instead of as formerly being made by a majority of the Directors, is now required to be made by "the President and Secretary of the meeting". In other respects, the law and procedure is as heretofore stated.' "

"Discussion was participated in by all present, Past-President Herschel especially calling attention to the fact that this Society really should have a charter from the Federal Government in order to be free from the details of a State law never intended to be inflicted on a National society of this character.

"On motion of Vice-President Hunt, seconded by Vice-President Stuart, and carried unanimously, the Acting Secretary was instructed to ask Parker and Aaron to prepare a resolution along the line suggested by them. —

"(3) Meaning of the words 'a written notice of such proposed amendment', as provided by Section 6 of Article X of the revised Constitution.

"The following opinion from Parker and Aaron, given under date of October 20th, 1921, was reported:

" 'In our opinion, the provision that an amendment shall be initiated by a written notice of such proposed amendment given at a previous meeting of the Board of Directors, requires that the proposer shall present a writing setting forth that he desires to propose an amendment to the Constitution, setting forth then the precise language of the amendment, with reference to the place in the Constitution where the amendment is to be, and shall further state in the writing that he intends to present and propose the said amendment at a subsequent meeting of the Board of Direction, which meeting shall be at least thirty days after the meeting at which the notice is given'."

"(4) As to the duties of the Secretary concerning ballots under the provisions of the second part of Section 9 of Article VII of the revised Constitution.

"The following opinion from Parker and Aaron, given under date of October 20th, 1921, in regard to this matter, was reported:

" 'With respect to the provision in Article VII, Section 9, that "no count or listing of votes cast in any Society canvass or election shall be permitted until after the polls are closed and then only by the officially appointed Committee or the Tellers", we do not find therein any requirement, to use the language of your letter, that "the ballots should be put in a box as received and not handled in any way thereafter, the whole matter of checking as to the eligibility of the voter, etc., being left to the Tellers". The only prohibition we see there is that a list or count of votes cast shall not be made by any one except the Committee or Tellers after the polls are closed. Any action by the Secretary under his general authority or under any special direction of the Board, which does not constitute a count or listing of votes cast, is not prohibited by Section 9 of Article VII.'

" 'We do not understand that the Secretary has any authority to pass upon the eligibility of a voter or upon the sufficiency or effect of his ballot. These matters are presumably to be determined by the Tellers after the polls are closed. If, however, upon receiving a ballot prior to election, the Secretary shall know or be aware of the fact that the voter is not a Corporate Member entitled to vote, or although a Corporate Member is disqualified for non-payment of dues or for some other reason from voting, we see no constitutional objection to his making a note of that fact and presenting it as information to the Tellers to facilitate their inquiry or examination. We, of course, express no opinion as to the advisability of any such procedure.'

" 'The matter of withdrawing ballots would seem to be one which the voter was entitled to exercise directly prior to the election, and the Secretary presumably would, upon proper identification, deliver to the voter any ballot deposited with him prior to the election. When two or more ballots are voted by the same voter, the determination as to which shall be counted is with

the Tellers and not with the Secretary. Presumably, if two such ballots appeared bearing different dates of deposit, the Tellers would count the one later in date and reject the earlier one, although it might well be that the Tellers would be legally justified in rejecting both when the voter had not withdrawn his former ballots'."

"In view of the foregoing, the Acting Secretary asked:

"'Shall each ballot, as received, be checked to see whether the member is entitled to vote, and thereafter arrange alphabetically according to Districts?'"

"On motion of Vice-President Hunt, seconded by Treasurer Hovey, and unanimously carried, the Acting Secretary was authorized and instructed to check each ballot as received in order to see whether the member is entitled to vote, and thereafter to arrange them alphabetically according to Districts, keeping separately those known to be out of order, such as from members in arrears for dues and not entitled to vote, or from non-corporate members, unsigned ballots, or those with rubber-stamp signature, etc., which are to be handed to the Tellers for rulings thereon.

"Vice-President Stuart reported progress in regard to his suggestion that from 100 to 250 men in the Profession be honored by the Society, and stated that he would try to have a report at the next meeting of the Committee to be held November 21st, 1921.

"The Acting Secretary reported that he had explained to the October Board meeting the necessity for an increase in the 1921 Budget of the items of Postage (from $12 000 to $15 000) and Publications (from $65 000 to $72 000), to provide for postage and printing Volume LXXXIV of *Transactions* and for postage for the Index to *Transactions;* and the action of the Board was to refer this, with the favorable recommendation of the Board, to the Finance Committee with power.

"On motion of Chairman Herschel of the Finance Committee, duly seconded and carried, the items of Postage and Publications were accordingly increased $3 000 and $7 000, respectively. [The item of $12 000 in the Budget for Technical Activities, is to be decreased by an equivalent amount.]

"The Acting Secretary reported that the October Board meeting referred the matter of establishing rules, etc., for the award of the Arthur M. Wellington Prize to this Committee with power and instructions to confer with the donor, and that he had spoken to E. J. Mehren, Affiliate, Am. Soc. C. E., Editor of *Engineering News-Record,* in regard to this, but Mr. Mehren stated that he did not care to specify anything further than was stated in January, 1921, when the Board accepted $2 000 to establish this prize, that is, that the prize is to be awarded annually for the best paper presented before the Society on any phase of the science of transportation, whether by land, water, or air, and will not be restricted to members of the Society.

"After discussion as to what form this prize should take, the following suggestions made by the Acting Secretary were, on motion of Vice-President Hunt, seconded by Treasurer Hovey, adopted as the action of this Committee:

"That the prize shall consist of $75 in cash, with an engraved certificate signed by the President and Secretary of the Society, the form of the certificate to be left to the Acting Secretary.

"For the information of the Committee, it was reported that Hiram F. Mills, Hon. M. Am. Soc. C. E., died on October 4th, 1921, and a Boston newspaper clipping forwarded by Past-President Herschel states that Mr. Mills bequeathed the Society $2 000, although formal notice of the fact has not yet been received.

"Adjourned at 3:50 P. M."

MINUTES OF MEETING OF EXECUTIVE COMMITTEE, NOVEMBER 21ST, 1921.

"The Executive Committee met at 1:40 P. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Herschel, Hovey, Hunt, and Stuart.

"It was announced that the minutes of the last meeting of the Committee held October 24th, 1921, had been forwarded to each Director.

"Vice-President Stuart's suggestion that from 100 to 250 men in the Profession be honored by the Society, originally made to the June Board meeting for the consideration of this Committee, was postponed indefinitely.

"At the last meeting of this Committee, the Acting Secretary was instructed to secure the advice of Counsel as to whether the Treasurer would be a member of the Board of Direction after the 1922 Annual Meeting until his successor is elected; and the following opinion from Parker and Aaron, given under date of November 2d, 1921, in regard to this matter, was reported:

" 'Our opinion is that, assuming a resolution is passed at the Annual Meeting changing the number of Directors in accordance with the amended Constitution, the office of Director now held by the Treasurer will terminate and Mr. Hovey will not continue to be a Director of the corporation. Inasmuch as the term for which he is elected expires at that time, the office may then lawfully be terminated and there is no holding over.'

" 'The question whether he will continue to be the Treasurer until his successor in that office is elected, is not free from doubt. The usual rule and practice is that officers of a corporation may continue in office until their successors are elected, or appointed, and in the absence of action by the Board of Direction terminating Mr. Hovey's duties as Treasurer, we think he would be qualified and entitled to continue as Treasurer until his successor is appointed by the Board of Direction pursuant to the provisions of the amended Constitution.' "

"The following letter was presented from Director Humphrey:

" 'NOVEMBER 19TH, 1921.

" 'Mr. George S. Webster, *President,*
American Society of Civil Engineers,
33 West 39th Street, New York, N. Y.

" 'My dear Mr. Webster.—The Executive Committee of the Board of Direction at its meeting on October 24th, 1921, authorized the omission of the name of the candidate for Treasurer from the ballot for officers to be canvassed at the 1922 Annual Meeting.'

" 'This action was taken on the opinion of Messrs. Parker and Aaron, which opinion assumes that the officers are elected at the 1922 Annual Meeting, whereas only the letter-ballots are canvassed at that time. The machinery of the Society for this election of officers having been set in motion at the meeting of the Nominating Committee last June, the result of which Committee action was announced in a circular, dated October 11th, 1921, to the corporate members of the Society giving the list of the nominees for the offices to be filled at the annual election January 18th, 1922; this list contained the name of Otis E. Hovey, nominated for the office of Treasurer.'

" 'The subsequent amendment of the Constitution of the Society cannot set aside action taken by the Society, under its Constitution, in accordance with the therein provided method for the election of officers which has its culmination at the 1922 Annual Meeting.'

" 'It is my opinion that the Executive Committee acted without authority; and that Mr. Hovey's name should be printed on the official ballot; and that the question of Mr. Hovey's right to hold office, if elected, should be decided by the Board of Direction, the only body, other than the Courts, competent to do so.'

" 'Respectfully submitted',

" 'RICHARD L. HUMPHREY'."

"For the information of the Committee, the following opinion from Parker and Aaron, given under date of November 2d, 1921, was reported:

" 'We have your favor of November 1st, 1921, requesting our opinion in the following matter, to-wit:'

" 'There are now six Directors from District 1, two of whom will retire on January 18th, 1922. Two Directors from District 1 have been nominated, and in accordance with Article VII (Transitory) of the By-Laws their names will be issued on the Ballot for Officers. If these Directors are elected, it will result in a representation of six Directors from District 1 and one each from each of the other twelve Districts.'

" 'Will this carry out the provisions of the new Constitution, more particularly those provisions in Article VII which relate to the Nomination and Election of Officers?'

" 'In reply, we beg to advise you that in our opinion the course indicated is in accordance with the provisions of your Constitution. In explanation of our opinion we may state that the election of Directors to be held at the Annual Meeting in January, 1922, should be conducted on the basis of the apportionment or districting now existing, that is, the thirteen districts as provided for by the Constitution prior to the revision taking effect this November are not *ipso facto* changed by the amendments, but the Board of Direction is empowered to re-district or review the existing divisions, and until it has made such review and change in the boundaries the present districts continue. Between January 1st, 1922, and April 1st, 1922, it will be the duty of the Board of Direction to review the several districts and if necessary make changes in their boundaries to conform to the requirements of Article VII as amended, announcing the district boundaries to the Corporate Membership not later than April 1st. It is obvious that the review and, if necessary, re-districting contemplated by this provision is intended to form a basis for the election of Directors next following April 1st, 1922, and not for the election of Directors occurring in January, 1922, because it is provided that the ballots for the election in January, 1922, shall be sent out at least thirty days prior to the Annual Meeting and they must, therefore, be sent out prior to January 1st, 1922, but the re-districting is expressly required to be made upon the basis of conditions on the first of January of the current calendar year, and the nominations to be made by the primary system provided in the amended Constitution for the following Annual Meeting are based upon the re-districting or review made between January 1st and April 1st of the year preceding the Annual Meeting in which the election is held.'

" 'We therefore have no doubt that the election of Directors in January, 1922, as in each succeeding year, is to be based upon the districting as existing on April 1st of the year preceding the election'."

"In the ensuing discussion, the previous letter from Parker and Aaron, dated October 22d, 1921, which had been presented to the last meeting of this Committee* regarding Counsel's opinion that President Webster will be a member of the Board for only two years more after the 1922 Annual Meeting, in accordance with the new Constitution, rather than for five years more in accordance with the old Constitution, was discussed.

"After general discussion, the Acting Secretary was instructed to secure an expression from Parker and Aaron as to whether by sending the name of Mr. Otis E. Hovey to ballot for Treasurer, we will make possible future action by the Board of Direction, and yet not prejudice or tie the hands of the Board, or the Society; in other words, whether sending out the name to ballot would result in any commitment. Further, to secure a clarification of the apparent inconsistency in Counsel's opinion that it would not be proper to include in the form of ballot any nomination for Treasurer, while the names

* See p. 211.

of two Directors for District No. 1 should be retained. In other words, why it is necessary to elect the two Directors from District No. 1 at the 1922 Annual Meeting, and not the Treasurer. Further to secure a clarification of the statement that the President is *ex-officio* a member of the Board of Direction.

"The Board of Direction at its meeting held October 10th, 1921, authorized the sale of the Fifty-seventh Street property by the Finance Committee [now the Executive Committee] whenever an advantageous opportunity is presented, placing a minimum net price of $600 000 thereon, on condition that the unanimous consent of the Committee, plus the approval of the then President, be obtained, provided advice of Counsel is to the effect that the Board has power to delegate such authority to the Committee.

"The following opinion from Parker and Aaron, given under date of October 26th, 1921, in regard to this matter, was reported:

" 'We acknowledge receipt of your letter of October 25th inquiring whether the Board of Directors has the power to delegate authority to sell the 57th Street property.'

" 'In reply, we beg to advise you that the Membership Corporations Law expressly requires that no sale of real property shall be made by a membership corporation unless ordered by the concurring vote of at least two-thirds of the whole number of its Directors; provided, however, that when the whole number of Directors is not less than twenty-one, the vote of a majority of the whole number shall be sufficient, and the statute further provides that when the real property is situated within the State of New York it shall not be sold without leave of Court.'

" 'Under these conditions, before any valid sale of your property on 57th Street can be made, a resolution approved by a majority of your whole Board of Direction will have to be passed ordering the sale upon terms agreed upon, and application will then be made by petition to the Supreme Court for its approval thereof, which approval it may be assumed will be granted.'

" 'The usual practice in such cases is to negotiate a contract of sale subject to the approval of the Board of Direction and subject to the approval of the Court. There is no reason why your Finance Committee could not be authorized to negotiate a contract of sale, which by its terms should be subject to the approval of the Board of Direction and further subject to the approval of the Supreme Court. In fact, we see no other way to sell the property than by the execution of a contract setting forth all the terms of the sale proposed and making the contract subject to the approval of the Board of Direction and of the Supreme Court'."

"No action.

"On motion of Vice-President Hunt, duly seconded and carried, authority was granted to engage an architect to prepare plans and specifications for necessary alterations to the sidewalk and vault space of the Fifty-seventh Street property required by City ordinance.

"On motion of Vice-President Hunt, duly seconded and carried, the bonds of both the Secretary and Treasurer were ordered placed in the custody of the President of the Society.

"The following letter from Dunbar and Rogers, Counsellors-at-Law, Lowell, Mass., dated November 15th, 1921, was reported:

" 'That the 27th article of the will of Mr. Hiram F. Mills, recently deceased, reads as follows:'

" '*Twenty-seventh:* To the American Society of Civil Engineers, of which I am an Honorary Member, the sum of Two Thousand ($2 000) Dollars.'

" 'As you doubtless know, under our law, legacies are payable in one year from the allowance of the will, but as action of the Probate Court occurs

only during the current week, the executors are, as yet, unable to form any plans or submit any predictions as to time of distribution'."

"No action.

"A letter of November 9th, 1921, was reported from Gen. R. C. Marshall, Jr., General Manager of the Associated General Contractors of America, addressed to President Webster, inviting this Society to assign a representative to attend a conference to be held at 10 A. M., Friday, December 15th, 1921, in Washington, D. C. (and subsequent deliberations of the Joint Committee) to establish more uniform contracting practice.

"On motion of Vice-President Hunt, seconded by Treasurer Hovey, and carried unanimously, the President was authorized to appoint such representative.

"President Webster appointed H. Eltinge Breed, M. Am. Soc. C. E.

"A letter of November 7th, 1921, was reported from Franklin H. Wentworth, Secretary of the National Fire Protection Association, citing the recent dock fire on the Jersey City water-front and emphasizing the supreme importance to the welfare of our country of the study which its Committee on Docks, Piers, and Wharves is making of the fire hazards of docks, piers, and wharves, and its effort to evolve reasonable regulations for the construction and fire protection of these properties. A copy of the report of the Committee has been received, and the suggestion is made that this Society appoint a Fire Prevention Committee to make a special study of the tentative regulations already formulated by the Committee and to co-operate with the Committee in its further attention to this subject. The statement is made that both the American Association of Port Authorities and the American Institute of Architects are taking steps toward the appointment of committees to co-operate in this manner.

"On motion of Past-President Herschel, duly seconded, and carried, this matter was referred to the Committee on Special Committees, with the favorable recommendation of the Executive Committee.

"Communications from the Kansas and New York Sections of the Society for assignment of funds to them, were presented, and considered in connection with the Budget for 1922.

"Adjourned at 4 P. M."

Minutes of Meeting of Executive Committee, December 6th, 1921.

"The Executive Committee met at 4:10 P. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Herschel, Hovey, Hunt, and Stuart.

"It was announced that the minutes of the last meeting of the Committee held November 21st, 1921, had been forwarded to each Director, and these minutes were approved.

"Messrs. Herschel and Hovey were appointed Tellers to canvass the ballots on Honorary Membership of Marshal Ferdinand Foch, which canvass resulted in his election as an Honorary Member of the Society.

"It is planned to present a joint certificate of Honorary Membership in this and the other three Founder Societies to Marshal Foch on December 13th, 1921.

"On motion, duly seconded, and carried, approval was given to payment of this Society's share in engrossing of such certificate.

"At the last meeting of this Committee, the Acting Secretary was instructed, and did, write to Parker and Aaron for further information concerning previous legal opinions received on certain points and clarification of alleged inconsistencies, and the following reply, dated November 28th, 1921, was reported, copy having already been forwarded each Director:

" 'New York, November 28th, 1921.

" 'Elbert M. Chandler, Esq., *Acting Secretary,*
American Society of Civil Engineers,
29 West 39th Street, City.

" 'Dear Sir.—We have your favor of November 23d, enclosing copy of letter of Mr. Richard L. Humphrey to Mr. Webster dated November 19th, 1921.'

" 'Complying with the request in your letter, we shall endeavor now to present in somewhat more detail the reasons for the conclusions which we have expressed in prior letters concerning the proper construction of the Constitution. Perhaps some misapprehension will be removed by a statement of the point of view from which the amendments must be approached.'

" 'Mr. Humphrey in his letter says:

"The subsequent amendment of the Constitution of the Society cannot set aside action taken by the Society, under its Constitution, in accordance with the therein provided method for the election of officers which has its culmination at the 1922 Annual Meeting."

" 'If this were a correct statement of the legal restriction upon amendments to the Constitution, to-wit, that they cannot affect or limit any procedure theretofore initiated, the conclusion reached by Mr. Humphrey would be correct. We are not, however, aware of any such restriction or limitation upon the power of amendment or the effects of amendment. As we view the law, any amendment of the Constitution of the American Society of Civil Engineers respecting the number of officers or their tenure or the manner of election, is, after its adoption, the sole rule and authority for the tenure of such officers and their method of election, subject only to the statutory limitation that such amendments shall not "change the term of office of any director then in office". With this exception, the officers of such a Society as yours have no vested or property right in their respective offices and an amendment of the Constitution terminating their office or changing the manner of election of their successor to office is in no respect invalid merely because it renders nugatory or interferes with earlier action of the Society. It would have been perfectly competent for the amendment to the Constitution, effective November 5th, 1921, to have contained provisions expressly abolishing or eliminating any action taken by the Nominating Committee under the provisions of the Constitution prior to revision.'

" 'In the absence of the so-called Transitory Provision from the Amendments, there would be no authority whatever for presenting at the 1922 Annual Meeting the names of the persons nominated by the Nominating Committee as official nominees. The only question that can exist with respect to the Constitution now in force, under which alone the January, 1922, election must be conducted, is whether the provisions of the Transitory Article authorize the Secretary to send out a letter-ballot to the Corporate Members with envelope for voting, containing the name of a candidate for Treasurer proposed by the Nominating Committee under the procedure in force prior to the adoption of the present revision. The question presented is not what "cannot" or "can" be done by way of amendment, but what is in fact the legal force of the amendment adopted.'

" 'We have expressed the opinion, in our letter to you of October 19th, that it was neither the purpose nor the legal effect of the Transitory Article to make any change in the officers to be elected at the January, 1922, meeting from that condition that would exist as matter of law in the absence of said Transitory Article, but that the true purpose and scope of said Transitory Article was to present as candidates for election to the offices to be filled at the January, 1922, election those names which had been recommended for those offices by the Nominating Committee.'

" 'It might well have been that certain offices existing prior to the amendment, and for which nominations had been made by the Nominating Com-

mittee, were abolished by the amendment. We would not, in such event, consider it proper to submit on the ballot the names of candidates recommended by the Nominating Committee for offices now non-existent. In the particular instance in question, the office of Treasurer has not been abolished, but it has been changed from an elective to an appointive office. No nominations by declaration for the office of Treasurer could properly be received or transmitted by the Secretary under the present Constitution, nor do we see any reason for transmitting on the ballot the nomination of the Nominating Committee for Treasurer when no election for such office is to be held.'

" 'In your letter of November 23d, you state:

"I am instructed by the Executive Committee to secure from you an expression as to whether by sending the name of Mr. Otis E. Hovey out to ballot for Treasurer, we will not make possible future action by the Board of Direction, and yet not prejudice or tie the hands of the Board, or the Society. In other words, would sending out the name to ballot result in any commitment?"

" 'In reply, we may say that we do not find in the Constitution any authority on the part of either the Secretary or the Board of Direction to send out to the Corporate Membership any name on a ballot for Treasurer. The legal effect would be a nullity. Whether the submission of the name of any particular candidate for Treasurer to the Corporate Membership for expression of an opinion would embarrass or hamper the action of the Board of Direction in performance of its constitutional duty to appoint such Treasurer shortly after the Annual Meeting, is a matter, not of law, but perhaps of ethics, with respect to which we make no suggestion.'

" 'You ask us to clarify the reasons why we consider it proper to elect two Directors from District No. 1 at the January, 1922, meeting in spite of our conclusion that the Treasurer should not be elected at that Annual Meeting. We see no connection whatever between the two matters. The Constitution prior to amendment provided for eighteen directors, and provided, for use in nominating candidates for directors, thirteen geographical districts, of which District No. 1 shall be the territory within fifty miles of the post office of the City of New York, and provides that nominees for these directors shall be such as will fill the Board of Directors with six directors residing in District No. 1 and twelve directors divided equally among the remaining districts. We find nothing in the revised Constitution changing the manner of electing directors, except as to the manner of the nomination of candidates, and, therefore, advise that the nominations and election for directors at the January, 1922, election should be as heretofore. Some time after January 1st, 1922, and prior to April 1st, 1922, the Board of Direction will re-examine the geographical districts and may change them and may make a re-apportionment of districts. Until that is done, however, the present Constitution of itself makes no changes in the geographical districts or in the number of directors to be nominated from them.'

" 'In considering this matter, it should be noted that the whole matter of geographical districts is not a matter of the election of directors, but of the selection of nominees to be called official nominees. There is no legal obligation on any Corporate Member to vote for any of these official nominees, so that the question is not as to whether the present Constitution requires the election of any particular number of directors from District No. 1. It certainly does not. But it does provide that the nominations for directors made by the Nominating Committee during the summer of 1921 should be presented as candidates to the Corporate Membership for voting upon at the January, 1922, election. The revised Constitution contains no other provision, whatever, with respect to the official nominees for directors at this meeting in January, 1922, and we are at a loss to see that any question arises with respect to the submission of the names of the directors to be voted upon at the

January, 1922, election. By the plain and unquestionable language of the Transitory Amendment, the nominees to be presented for voting upon to the Corporate Membership are the nominees for directors recommended by the 1921 Nominating Committee plus nominations made by declaration pursuant to provisions of the Constitution now in force.'

"'This brings us to the final question in your letter, asking an explanation of our expression that the President is *ex-officio* a member of the Board of Direction. It is obvious that the Board of Direction of your Society is composed of a number of officers holding different offices. The President holds the office of President; the Vice-President holds the office of Vice-President; the Director holds the office of Director. The President is not a Director, any more than the Director is a President, but each of these officers is a member of the Board of Direction, or constitute, as the Charter of the Society describes them, "the Trustees to manage the concerns of the Society". The President, because he is President, is one of these Trustees. The Director, because he is a Director, is one of these Trustees. The President is not a Director by reason of his office, but he is a member of the Board of Direction by reason of his office, and in the same way the Director is not a President by virtue of his office, but is a member of the Trustees or Board of Direction by reason of his office. Each of the officers holds membership on the Board of Direction *virtute officii,* or, as we more commonly say, *ex-officio,* because membership on the Board of Direction is an appurtenance to, duty, and privilege of the office which he respectively may hold.'

"'It is this view of the composition of the Trustees or Board of Direction of your Society which leads us to the conclusion that the statutory inhibition of changing the term of a Director then in office by an amendment to the by-laws of a membership corporation should be construed to apply to the particular office by reason or by virtue of which the officer is a member of the Directory. In this connection, the title of the officer, whether it be Trustee, Director, Treasurer, or President, is not significant. The question is what office is he holding and what is the term of that office. As we view it, the President is a member of the Board of Direction because he holds the office of President, and that officer is by the Constitution a member of the Board of Trustees or Board of Direction. The term for which he holds office is the term of the President, to wit, one year. In like manner certain Past-Presidents hold office on the Board of Direction. The term for which they hold is an indeterminate period, to wit, so long as they shall respectively be among the five latest living Past-Presidents. The offices held by these five latest living Past-Presidents now have incumbents, and it is not until one of these offices is vacant that the present President of the Society will become a member of the Board of Direction for a term of the character now held by the five latest living Past-Presidents. Our view, and we expressed it with some diffidence, is that the statutory provision does not apply to such an office to which he is now heir apparent, and that therefore the amendment to the Constitution changing the composition of the Board of Directors from the five latest living Past-Presidents to the two latest living Past-Presidents may lawfully take effect as against all officers of the Society except the present incumbents thereof, to wit, the present five latest living Past-Presidents, who, in our opinion, are the only persons holding positions on the Board of Direction whose legal office would otherwise be terminated by the mere going into effect of the revised Constitution.'

"'We hope that we have sufficiently explained our views in these matters, which of course are opinions merely about matters, with respect to at least some of which a contrary view may reasonably be argued.'

"'Very truly yours,

"'Parker and Aaron'."

"On motion of Treasurer Hovey, seconded by Past-President Herschel, and carried unanimously, the Acting Secretary was instructed not to issue the name of Otis E. Hovey as a candidate for Treasurer on the Ballot for Officers to be canvassed at the 1922 Annual Meeting.

"The Acting Secretary submitted the proposed form of ballot, which was approved.

"The matter was discussed as to whether the professional records of members, which are now being received in response to circularization therefor, shall be available to the public, the question having been brought up by two members.

"It was decided to reply that it was intended that the records should be available to all inquirers, as stated in the letter transmitting the forms, but the matter would be brought to the attention of the incoming Board of Direction next year for further action if necessary.

"Authority was granted to contribute $20, as was done last year, to the Fifth Avenue Association.

"The matter of members in arrears for dues was discussed, and it was decided that Vice-Chairman Herschel should go over these cases and incorporate in a report to the Board of Direction, for the Committee, recommendations as to appropriate action, at the same time as the matter of resignations previously referred to Mr. Herschel and the Acting Secretary is reported on.

"The resignation of George H. Pegram, Past-President, as a member of the Special Committee on Bridge Design and Construction was reported.

"Action was postponed until the January Board meeting.

"Adjourned at 5:15 P. M."

Minutes of Meeting of Executive Committee, December 20th, 1921.

"The Executive Committee met at 3:30 P. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Herschel, Hovey, Hunt, and Stuart (came in at 3:50 P. M.).

"It was announced that the minutes of the last meeting of the Committee, held December 6th, 1921, had been forwarded to each Director, and these minutes were approved.

"It was also reported that Messrs. Howard Adams Carson and Charles Prosper Eugene Schneider had accepted election to Honorary Membership, and expressed their appreciation thereof, but regretted they could not be present at the Annual Meeting; that they (as well as Mr. Luigi Luiggi) had been written to and asked whether they would be willing to designate some one to represent them at the Annual Meeting when the Honorary Membership certificates will be awarded.

"This action was approved.

"The Acting Secretary reported that at the Board meeting on October 10th, 1921, the President was authorized to appoint a Local Committee on Arrangements for the Annual Meeting, and that subsequently he had appointed Messrs. J. P. H. Perry, Chairman, Laurence A. Ball, Charles Hansel, Nelson P. Lewis, Robert Ridgway, Merritt H. Smith, and Daniel L. Turner. The program for the Annual Meeting was issued December 17th, 1921, and it is understood there will be a later announcement which will give the speakers at the technical meetings.

"Also, that the Committee of the Board on the Annual Meeting had had a meeting on December 14th, 1921, and had requested the Acting Secretary to present to the Executive Committee a request for an increased appropriation of $1 500 for the Annual Meeting.

"After a general discussion, on motion of Vice-President Hunt, duly seconded, and carried, the request of the Committee of the Board in charge of the Annual Meeting was declined, with the explanation that the funds of the Society are pledged so that it does not seem advisable to make such

an appropriation, especially in view of the necessity which is before the Society of providing for the return of a portion of the membership dues to Local Sections.

"The advisability of hereafter including notices of reunions of other organizations in the Annual Meeting program of this Society was discussed.

"On motion of Treasurer Hovey, duly seconded, and carried, it was decided that such announcements may be published at the discretion of the Committee in charge of the Annual Meeting, but that they are to be as brief as possible.

"On motion of Vice-President Hunt, duly seconded, and carried, the President was authorized to appoint the necessary Tellers to canvass the Ballots for Officers. The Tellers are to start the canvass at 9 A. M. [which is the hour prescribed in the Constitution for closing the polls], Wednesday, January 18th, 1922.

"Discussion was had as to when the new President would preside, and this was concluded to be after the close of the Business Meeting of the Annual Meeting.

"A letter was read from Verne LeRoy Havens, M. Am. Soc. C. E., dated December 17th, 1921, outlining a proposed Congress to be held in Rio de Janeiro, Brazil, in September, 1922.

"It was decided this was a matter for the incoming Board of Direction to pass on.

"A letter was presented from H. Foster Bain, Director, U. S. Bureau of Mines, and S. W. Stratton, Director, U. S. Bureau of Standards, dated November 21st, 1921, inviting this Society to appoint a representative who will act as a member of the Advisory Board to these Bureaus in conducting an investigation on 'the breakage and heat treatment of rock drill steels and other steels and alloys subjected to similar impact stresses.'

"On motion of Vice-President Hunt, seconded by Vice-President Stuart, and unanimously carried, the President was authorized to appoint such representative.

"On motion of Past-President Herschel, duly seconded, and carried, approval was given to the admission of the Association of American Steel Manufacturers and the American Railway Engineering Association as member bodies of the American Engineering Standards Committee, which Committee had already voted unanimously in favor of their admission.

"The Acting Secretary reported the following as a matter of record:

"That in answer to an invitation to this Society to be represented at a conference on consideration of the possibility of the elimination of excess variety and style in paving brick held November 15th, 1921, in Washington, D. C., President Webster had appointed William D. Uhler, M. Am. Soc. C. E., who had accepted.

"The re-appointment by President Webster of F. H. Constant, M. Am. Soc. C. E., as one of the four representatives of the Society on the Library Board of Engineering Societies Library for the four-year term ending December 31st, 1925, which appointment he had accepted.

"After full discussion and a tentative motion concerning the possibility of renting the Past-Presidents' Room, on motion of Vice-President Hunt, duly seconded, and carried, it was decided that the matter should go over until the next Board meeting. Meanwhile, the Acting Secretary is to formulate a report covering the portraits of the Past-Presidents.

"The Acting Secretary asked for a ruling as to whether the term 'Registered' should be given in the Year Book before the words, 'Architect, or Civil, Mining, Mechanical or Electrical Engineers.'

"After discussion, on motion of Vice-President Hunt, seconded by Treasurer Hovey, and carried, it was decided that for the present issue of the Year Book such designations should be omitted.

"The applications of a dozen Student Chapters were reported, but it was decided these should go over for the approval of the full Board meeting in January. Meanwhile, the Committee on Student Chapters, of which Director Marston is Chairman, is to report on these cases, and is also to formulate a basis for the consideration of future cases.

"Adjourned at 5 P. M."

The President appointed Messrs. Brown, Elwell, and Greene, as Tellers to canvass the Membership Ballot. The Tellers subsequently reported and the President declared the election of candidates.

Acting Chairman Humphrey, of the Publication Committee, reported progress.

REPORT OF COMMITTEE ON SPECIAL COMMITTEES

Chairman Davis, of the Committee on Special Committees, presented the following report which, on motion, duly seconded, and carried, was received:

"NEW YORK, January 16th, 1922.

"HON. GEORGE S. WEBSTER,
President Am. Soc. C. E.

"SIR.—The Committee on Committees has the honor to submit the following report:

"Special Committee on Electrification of Steam Railways.

"It has been proposed that a Special Committee be appointed to consider the Electrification of Steam Railways in co-operation with similar committees of other Societies.

"Some of our members specializing in electrical installation have advised against its appointment, because good results cannot be expected and also with the feeling that it would be an invasion of the field of private practice.

"The broad question, however, has a public interest of great importance, especially in the East, where density of traffic is in many cases sufficient to afford large economy in electrification, which would also conserve the coal supply, and in the Far West, where it would conserve our exhaustible high grade fuel oil, and would also be financially economical, in some cases.

"The interests of the public would be promoted either by the appointment of a commission or an investigator, as the Government has done, or by the work of committees of the National Societies.

"This public interest is mainly based on the conservation of oil and coal, and other objects which would not be moving factors on the side of the steam railroads. On the other hand, the steam railroads would be assisted in financing the change by popular support, which could be gained through the endorsement of such organizations as the National Engineering Societies.

"While doubtful of its expediency, your Committee nevertheless recommends that a Special Committee of Seven be appointed by the President on the Electrification of Steam Railways, to co-operate with similar committees of the other National Societies, provided members of National standing are found willing to serve on such a committee.

"Committee on Topographic Maps.

"The Board has on June 6th, 1921, already passed resolutions* favoring early completion of the topographic map of the country, so that a committee on this subject appears to be unnecessary.

"Committee on Stresses for Structural Steel.

"Relative to the proposal for a committee 'To determine from tests the working stresses for structural steel', your Committee believes that such a committee may be advisable in the future, but its appointment might best

* *Proceedings,* Am. Soc. C. E., August, 1921, p. 589.

await the results of the work of the Special Committee on Bridge Specifications, and the Researches on the Fatigue of Metals now under way by the National Research Council. We recommend that the question be referred to the Committee on Research.

"Committee on Fire Protection.

"This Society could not have a Standing Committee on Fire Protection unless it were a member of the National Fire Protection Association, because such a subject is not within the scope of the objects of this Society.

"The Society has been requested to suggest the appointment of a Special Committee to consider the report made to the National Fire Protection Association, November 7th, 1921, on the fire hazard of docks, piers, and wharves, and in co-operation with the committees of other Associations to analyze the regulations proposed in the report with the object of their general adoption and future extension.

"Your Committee would recommend that such a Special Committee of Seven be appointed by the President, with the restriction that final report must be made within a year.

"Respectfully submitted,

"A. P. Davis,
"George H. Pegram,
"Anson Marston,
"Committee on Special Committees."

Discussion was participated in by Messrs. Alvord, Brown, Cummings, Curtis, Davis, Herschel, Hudson, Humphrey, Pegram, and Talbot. On motion, duly seconded, and carried, the recommendations of the report were adopted with the addition of the words, "and prevention", to the last recommendation regarding the Committee on Fire Protection.

Committee on Licensing Engineers

Chairman Humphrey, of the Committee on Licensing Engineers, asked for postponement of the report of his Committee until later in the session, which request was granted.

The Acting Secretary requested instructions in regard to the payment for mimeographing 150 copies of the hearings of this Committee, for which there was no appropriation.

Director Humphrey addressed the Board concerning this matter, and Past-President Davis suggested the possibility of condensing the minutes of these hearings.

President Webster suggested postponing consideration of the matter until the Committee is ready to report.

Director Anderson so moved, and this was ordered done.

Code of Ethics

Director Elwell who, with Vice-President Hunt, represented the Society on a Joint Committee on Proposed Universal Code of Ethics, common to all engineers and architects, reported progress.

Report of Committee on Senate Bill Re Encouragement of Agricultural Resources of the United States

Director Grunsky, of the Committee to Report on Senate Bill *re* the Encouragement of Agricultural Resources of the United States, explained that

Past-President Davis who was originally appointed Chairman of the Committee, thought it best not to serve, and that he and Mr. Anderson had formulated the following report:

"NEW YORK, January 16th, 1922.

"TO THE BOARD OF DIRECTION,
Am. Soc. C. E.

"Your Committee to consider the matter of engineers taking an active part in furthering legislation looking toward the development of the nation's natural resources, has had referred to it copies of a pamphlet entitled 'Hearings before the Committee on Irrigation of Arid Lands, House of Representatives on H. R. 2913, by Mr. Smith of Idaho, a Bill to Encourage the Development of the Agricultural Resources of the United States, Through Federal and State Co-operation, Giving Preference in the Matter of Employment and the Establishment of Rural Homes to Those Who Have Served with the Military and Naval Forces of the United States' and the Committee has also had before it Senate Bill No. 2194 by Senator Borah.

"It appears from these documents that the question is pending in Congress as to the desirability of aiding land reclamation and land settlement enterprises to a greater extent and in a wider field than is now done under the provisions of the U. S. Reclamation Act.

"The proposed aid as contemplated by the measures now pending in Congress relates particularly to the reclamation of: (*a*) Arid lands by irrigation; (*b*) of swamp lands by drainage; and (*c*) of cut-over forest areas by community effort.

"Financial assistance is contemplated through the medium of Government credit, it being evident that money can be borrowed at lower rates of interest by the United States than by local districts.

"Your Committee is not prepared to endorse any particular measure now before Congress, but believes it to be a fundamentally sound policy that the several States should lend their credit to economically sound community enterprises for the establishment of rural homes and that similar aid by the United States directly or in co-operation with the several States and particularly in cases involving interstate interests would be of material advantage to the nation.

"Your Committee further believes that there are no other natural resources more worthy of early development under Federal and State aid than the water resources of the country and the Committee recommends as policies to be adopted and advocated by this Society the following:

"The regulation of stream flow by storage, in the interest of all possible uses of water, such as generation of power, irrigation, domestic supply, and the control of floods, should be effected by the United States in case of interstate streams and by the several States in the case of those streams whose water-sheds are entirely within individual States. All rights and permits granted to private concerns for water storage should be subject to State or Federal control of reservoirs.

"State and Federal aid to community enterprises for the extension of arable areas and to the settlers on such areas, with preference to war veterans, is favored by this Society.

"C. E. GRUNSKY,
"GEORGE G. ANDERSON,
"Committee."

After discussion, participated in by Messrs. Anderson, Henny, Hogan, Hudson, Humphrey, and Stuart, it was decided to defer action until later and, meanwhile, the Acting Secretary was asked to furnish a copy of the report to each Director.

Chairman Brown, of the Committee to Consider the Whole Question of the Status of the Civil Engineer in Government Work and his Compensation, reported progress.

FUNDS FOR BUST OF CAPTAIN EADS

The Acting Secretary presented for Chairman Wall, of the Committee to Prepare a Policy for the Collection of Funds for a Bust of Captain Eads, the following report:

"JANUARY 16th, 1922.

"BOARD OF DIRECTION,
American Soc. C. E.,
New York, N. Y.

"GENTLEMEN.—Your Committee appointed to prepare a policy for collection of funds for the Eads bust in the Hall of Fame of the New York University is of the opinion that the fund should be raised by a popular subscription, to which all members of the Society should have an opportunity to contribute. We therefore recommend that the Secretary be instructed to send a communication to each member of the Society, stating that Captain Eads is the only Engineer honored by a place in this Pantheon of the New World, and that in view of his distinguished career, which has reflected so much credit on the Engineering Profession, the American Society of Civil Engineers, of which he was a Vice-President, requests from its members contributions of from One to Five Dollars each, so that the cost of the bust may be shared in by many engineers as a tribute to the memory of one great engineer.

"Also, that there will probably be a public ceremony of unveiling busts at the Hall of Fame in May, 1922, so that subscriptions should be in the hands of the Secretary by March 1st, 1922.

"Also, for the information of the members, that the Art Committee of the Hall of Fame has decided that the pedestals of busts shall be of green marble fourteen inches wide and twenty-seven inches high and that the bust shall be thirty inches from the top of the pedestal to the scalp and ten inches from the shoulders to the scalp.

"With this communication to each member, the Committee recommends that there be inclosed a copy of the brief sketch of the life of Captain Eads, * * *

"Respectfully submitted,
"GEO. H. PEGRAM,
"EDWARD E. WALL,
"GEO. S. DAVISON*
"Committee."

Approved by A. S. BALDWIN, by letter.

This matter was discussed by Messrs. Grunsky, Henny, Hogan, Hudson, Humphrey, Pegram, Stuart, Talbot, and Wall, who presented a letter from Past-President Onward Bates suggesting that the cost of the bust be underwritten.

On motion of Director Brown, seconded by Director Henny, and duly carried, the report was adopted.

Subsequently, on motion of Director Hogan, seconded by Director Alvord, and carried, this Committee was continued with power to act.

On motion of Director Humphrey, recess was taken for luncheon at 12:45 P. M.

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* Authorized by telegram.

The Board reconvened at 2 P. M., with the same attendance as in the forenoon.

1922 Annual Convention

Past-President Curtis and Director Elwell addressed the Board concerning the time and place for the 1922 Annual Convention, as they had been asked by the Board to look into the matter.

The question was also discussed by Messrs. Alvord, Anderson, Davis, Grunsky, Herschel, Hogan, Hoyt, Hudson, Humphrey, Stuart, and Talbot.

After several tentative motions, informal ballot, and votes by show of hands, it was decided to refer the matter to the incoming Board, with the recommendation that the 1922 Convention be held in the White Mountains.

Annual Report of the Board of Direction

The Acting Secretary announced that the Chairmen of the Standing Committees of the Board had been appointed as a Committee to Prepare the Annual Report, copies of which were presented.

Messrs. Anderson, Cummings, Grunsky, Herschel, Hoyt, Hudson, Humphrey, and Talbot participated in the discussion and after some corrections, the report was adopted.

Student Chapters

Chairman Marston, of the Committee on Student Chapters, presented the following report, action being taken on each recommendation separately:

"New York, N. Y., January 16th, 1922.

"Board of Direction, Am. Soc. C. E.,
New York City.

"Gentlemen.—Your Committee on Student Chapters hereby report our recommendations on the various questions which you have referred to us as follows:

"1.—Re the request of certain Student Chapters (of the Universities of Cincinnati and of North Carolina) to be permitted to retain their local names (Braune Civil Engineering Society and William Cain Civil Engineering Society in the two schools named), we recommend that the foot-note applying to Section 1, Article V, of the By-Laws be amended by adding the following words:

" 'Chapters which desire to retain local names well established by tradition may do so by inserting such local names followed immediately by the name of the institution in parentheses, for example, "William Cain (University of North Carolina)".'

"2.—Re the question of changing the time of payment of dues of Student Chapters, because our fiscal year does not conform to the college year, we recommend amending Section 6, Article V of the By-Laws, by striking out the last paragraph and inserting the following in lieu thereof:

" 'The annual dues shall apply to the year beginning July 1st, and shall be due October 1st of such year. Each Chapter which has paid its dues for 1922, shall be required to pay only $5 on October 1st, 1922. Student Chapters admitted on or after January 1st of each year shall pay only $5 for the remainder of the current year to July 1st.'

"3.—Re the request from certain Student Chapters that members be permitted to wear pins, and in view of the report to us by the Acting Secretary that the American Society of Mechanical Engineers and the American Institute of Electrical Engineers grant their Student Chapters this privilege,

we recommend that members in good standing of Student Chapters of the American Society of Civil Engineers be authorized to wear a circular button bearing a miniature shield surmounted by the word 'Student', with the letters, 'A. S. C. E.', within the shield. If this recommendation be adopted we recommend that the colors and other details of the design not prescribed above, including the price, shall be referred to the Acting Secretary to investigate and to report back to the Board of Direction, after which a new Section of Article V of the By-Laws will need to be prepared and adopted in the manner prescribed by the Constitution.

"4.—Re pending application for admission of Student Chapters, we call attention to Section 1, Article V, By-Laws, which prescribes that one of the qualifications required of a proposed Student Chapter shall be:

"'(*A*).—An organization of students in an engineering school of high standing.'

"We recommend favorable action upon the admission of Student Chapters at:

"Carnegie Institute of Technology,
"Lafayette College,
"Lehigh University,
"Montana State College,
"University of Missouri,
"Ohio State University,
"Virginia Polytechnic Institute.

"Respectfully submitted,

"ANSON MARSTON,
"A. N. TALBOT,
"C. W. HUDSON."

The first recommendation in the report of the Committee was discussed by Messrs. Cummings, Davis, Hoyt, Humphrey, Marston, and Talbot.

Director Marston's motion that the recommendation of the Committee be against changing the By-Laws, as suggested in the report of the Committee, was lost by show of hands resulting in 9 "ayes" and 12 "noes".

Director Marston's motion that the recommendation of the Committee be approved, was then carried. (This is to be considered as the written notice of proposed amendment to the By-Laws required by the Constitution, and action thereon will be taken at the next meeting of this Board.)

On motion of Director Marston, seconded by Director Beahan, and carried, the second recommendation in the report of the Committee was approved. (This is to be considered as the written notice of proposed amendment to the By-Laws required by the Constitution, and action thereon will be taken at the next meeting of this Board.)

The third recommendation of the report of the Committee regarding Pins for Student Chapters, was discussed by Messrs. Cummings, Elwell, Humphrey, Talbot, and Wall.

On motion of Director Marston, seconded by Director Beahan, and carried, the third recommendation in the Committee's report was approved, with the additional instructions to the Acting Secretary to investigate also the matter of Pins for Juniors.

The final recommendations of the report of the Committee were discussed by Messrs. Cummings, Hoyt, Marston, Stuart, and Talbot.

On motion of Director Marston, seconded by Director Beahan, the applications of the Student Chapters favorably recommended by the Committee were unanimously approved.

More time was granted the Committee to formulate a report on the criterion to be adopted for admission of Student Chapters.

Copies of the report of the Committee on Senate Bill *re* Encouragement of Agricultural Resources of the United States previously referred to in these minutes, were distributed.

On motion of Director Hogan, duly seconded, and carried, this matter was postponed until the first meeting of the incoming Board.

Director Humphrey explained that the other two members of the Committee to Report on Rearrangement of the Fifteenth Floor will retire from the Board after the Annual Meeting, but he recommended that the Committee be continued as at present constituted.

Code of Ethics

The Acting Secretary presented the following report of the Joint Committee on a Code of Ethics for Engineers:

"The Joint Committee consisting of representatives of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Society of Heating and Ventilating Engineers, appointed to consider a Code of Ethics for Engineers recommends, after deliberate consideration, that each participating Institute or Society adopt the short simple Code of Ethics following this report.

"The Committee further recommends that the following method of interpreting and administering the Code be adopted by each participating Institute or Society after any necessary provisions have been made in the Constitution and By-Laws of the organization:

" 'The President of each Society or Institute shall appoint a Standing Committee on Professional Conduct, to administer the Code of Ethics. The duties of such a Committee shall be to interpret the Code and to render opinions on any cases of questionable conduct on the part of members that may be submitted to the Committee. These interpretations shall be reported to the Executive Board of the Institute or Society who may approve these interpretations, or take such other action as may seem just and necessary. The reports of the Committee on Professional Conduct when approved by the Executive Board, shall be printed in abstract and in anonymous form in the Institute's or Society's monthly journal for the instruction and guidance of fellow members.'

" 'This Committee on Professional Conduct shall be appointed in each Institute or Society by the President holding office at the time of the adoption of this Code and shall consist of five members, one appointed for five years, one for four years, a third for three years, a fourth for two years, and a fifth member for one year only. Thereafter, the President then holding office shall appoint one member annually to serve for five years, and shall also fill any vacancies that may occur for the unexpired term of the member who has withdrawn. These appointments shall be made from among the older members of the Institute or Society, so that advantage may be taken of their mature experience and judgment. The Committee after appointment shall elect its own chairman and secretary. The Committee shall have power to secure evidence or other information in any particular case not only from the organization's own members, but if it should seem desirable, from men in other professions. The Committee may also appoint sub-committees to consider certain cases when deemed necessary.'

" 'This Committee shall investigate all complaints submitted to it by the Secretary of the Institute or Society bearing upon the professional conduct

of any member and after the member involved has been given a fair opportunity to be heard, the Committee shall report its findings to the Executive Board of the Institute or Society. This report may in some cases suggest certain procedure of the Executive Board.'

"'The Executive Board of the Institute or Society shall have power to act on the recommendation of the Committee on Professional Conduct, either (1) to censure by letter the conduct of the member who has acted contrary to the Code, if the breach is of a minor character; or (2) to cause the member's name to be stricken from the roll of the Institute or Society.'

"'Copies of all reports made by a Committee on Professional Conduct to the Executive Board of each Institute or Society shall be furnished to each other Committee on Professional Conduct administering the Code. This will keep each Committee advised of the interpretations of other Committees, and in time an extended interpretation of the Code can be written based on the reports of the various Committees on Professional Conduct.'

"'As interpretations of the various Committees on Professional Conduct administering this Code may vary at times, it is recommended that the Chairman of these Committees of the various Institutes or Societies be authorized to act as a Joint Committee to review such differing interpretations and to bring them into unity with one another.'

"Respectfully submitted,

"Joint Committee on Code of Ethics,

"A. S. C. E.	C. C. Elwell, A. M. Hunt,	"A. I. E. E.	Comfort A. Adams, G. Faccioli, Geo. F. Sever, L. B. Stillwell,
"A. I. M. E.	J. Parke Channing, Philip W. Henry,	"A. S. H. V. E.	Frank T. Chapman, S. A. Jellett, Perry West."
"A. S. M. E.	A. G. Christie, *Chairman*, H. J. Hinchey, Chas. T. Main, J. V. Martenis, Robert Sibley,		

"A Code of Ethics for Engineers

"Engineering work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The Engineering Profession is held responsible for the planning, construction, and operation of such work and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

"That the dignity of their chosen profession may be maintained, it is the duty of all engineers to conduct themselves according to the principles of the following Code of Ethics:

"1. The Engineer will carry on his professional work in a spirit of fairness to employees and contractors, fidelity to clients and employers, loyalty to his country, and devotion to high ideals of courtesy and personal honor.

"2. He will refrain from associating himself with or allowing the use of his name by an enterprise of questionable character.

"3. He will advertise only in a dignified manner, being careful to avoid misleading statements.

"4. He will regard as confidential any information obtained by him as to the business affairs and technical methods or processes of a client or employer.

"5. He will inform a client or employer of any business connections, interests, or affiliations which might influence his judgment or impair the disinterested quality of his services.

"6. He will refrain from using any improper or questionable methods of soliciting professional work and will decline to pay or to accept commissions for securing such work.

"7. He will accept compensation, financial or otherwise, for a particular service, from one source only, except with the full knowledge and consent of all interested parties.

"8. He will not use unfair means to win professional advancement or to injure the chances of another engineer to secure and hold employment.

"9. He will co-operate in upbuilding the Engineering Profession by exchanging general information and experience with his fellow engineers and students of engineering and also by contributing to work of engineering societies, schools of applied science, and the technical press.

"10. He will interest himself in the public welfare in behalf of which he will be ready to apply his special knowledge, skill, and training for the use and benefit of mankind."

This matter was discussed by Messrs. Alvord, Anderson, Cummings, Curtis, Davis, Grunsky, Herschel, Hudson, Humphrey, Stuart, Talbot, and Wall; the Acting Secretary also presented a letter of October 24th, 1921, from W. J. Wilgus, M. Am. Soc. C. E., in connection with the alleged violation of the Code of Ethics of this Society by certain of its members, which matter was considered by this Board at its October, 1921, meeting, in which letter Col. Wilgus stated:

"I am very hopeful that the Board of Direction of the Society may see the wisdom of adopting a course something like that in vogue with the American Institute of Consulting Engineers for the consideration of matters bearing on ethics, with a view to the gradual accumulation of a series of impersonal findings which in time will clarify the obligations of the members of the profession toward each other and toward the Society."

On motion of Director Grunsky, seconded by Director Humphrey, and carried, the report of the Joint Committee on Code of Ethics was received and the matter referred to the incoming Board with the understanding that the following remarks of Director Alvord (whose term as a Director expires after the Annual Meeting) would be presented to the new Board:

"Codes of ethics have been a failure, in my opinion, in all our Societies, and the reason that they are a failure, particularly in this Society, is that they are either offered to hang a man or let him go 'scot' free and it is pretty difficult to decide sometimes whether he should go 'scot' free or should be hung. Now, in my opinion, we do not go about it right. I think a great many of the offenses committed against good ethical conduct are born of youthful ambition and struggle against natural conditions, which obscure for the moment, on the part of the party, a broad point of view and it seems to me if there were some machinery set up by which the older members of the Society could, in an advisory way, call attention of the members of the Society to correct ethical attitude, for minor infractions, simply an advisory letter coming from the committee with the proper spirit—it seems to me that would be very effective in a great majority of cases and, then, in another grade of discipline, a little higher, some publicity, either in the records of the Society or through some minor way expressing the fact that the Society's Ethics did not countenance such procedure, but not to the extent of being offensive discipline. Then you might go on to another scale of more flagrant violations—violations that really come to the point of dishonesty and dishonor—and have a discipline such as suspension or public reprimand and all these might well precede the hanging process—that is the only thing we have in our Constitution. Of course, there would be cases so flagrant and so obnoxious to the principles of the Profession that a member ought to be suspended, but I think that ought to be the last resort. Now, there is another point in my mind—it has always seemed to be one of the difficulties in writing Codes of Ethics—most Codes of Ethics are written from a stand-

point of a man who is practicing his Profession in Consulting Engineering. but the vast majority of our members are on a salary basis and most Codes of Ethics prohibit either directly or indirectly competition. Now, I think that is perfectly foolish. I think that competition is a necessity in the Engineering Profession. I believe there is an honorable way to compete and a dishonorable way of competition and that the dishonorable way should be discouraged. We have these two stages, one of which is an admonishing and the other a hanging and it does not strike me that gives enough latitude for the cases which arise. If I am right I believe that a great majority of young engineers would be very glad to have called to their attention, in a friendly and fine manner, what is good practice in Ethics and Engineering and it would do them lots of good—and I believe that nine-tenths of our cases arise from ignorance and inability to know what good ethics is from the more mature members of the Society.

"This is only getting 'off my chest' some thoughts which came to me when our Committee wrote the Code of Ethics for the Western Society. I do not think that was a model Code of Ethics but I do think a committee of the Society such as we have in the Institute of Consulting Engineers is a good move. That committee did undertake in a broad way an admonition of members who either inadvertently or intentionally violate good precedent."

In this connection, Director Humphrey moved that favorable recommendation be made to the incoming Board for the appointment of a Committee on Professional Conduct. This motion was seconded by Director Hudson, and carried.

On motion of Director Hogan, duly seconded, and carried, it was decided to adjourn at 5 P. M., until 8 P. M.

Adjourned at 5 P. M.

The Board reconvened at 8 P. M., with the same attendance as previously, except that Messrs. Brown, Davis, Elwell, Greene, Langthorn, and O'Connor were absent.

Requisite Minimum Membership of Student Chapters

In accordance with the action of the Board at its meeting on October 10th, 1921, at which written notice was given that it was proposed to change Article V, Section 2, Paragraph (*c*), of the By-laws of the new Constitution, each Director was notified under date of November 7th, 1921, of such amendment.

This amendment changes the By-laws at present requiring "a minimum membership of twenty students" for a Student Chapter to "a minimum membership of twelve students."

This matter was discussed by Messrs. Alvord, Anderson, Grunsky, Hogan, Hovey, Hudson, Marston, and Talbot.

Director Grunsky moved the adoption of the amendment. This motion was seconded by Director Hogan, and carried.

The Acting Secretary reported that at the meeting of the Board held April 17th, 1917,* it was:

"*Resolved:* That no officer of the Society shall officially recommend any one for any office or position."

and this matter was directed to be put in the By-laws when such By-laws are adopted.

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* *Proceedings*, Am. Soc. C. E., May, 1917, p. 313.

This resolution was discussed by Messrs. Herschel, Hudson, Humphrey, Talbot and Webster.

On motion of Director Humphrey, seconded by Director Hudson, it was laid on the table.

New Pay Employment Bureau

At the Board meeting of October 11th, 1921, the President was authorized to appoint a representative from the Board on a Joint Committee of nine members on Engineering Employment, with power to organize an Employment Bureau, and President Webster subsequently appointed Director Humphrey as such representative.

Director Humphrey made a verbal progress report.

On motion of Past-President Talbot, duly seconded, and carried, it was decided that Director Humphrey should continue as the representative in this matter until a further plan is worked out.

At the Board meeting of October 11th, 1921, on motion of Director Humphrey, the Society's representatives on the United Engineering Society were asked to look into the question of recommendation made as to the ground floor of this Building, and a reply of October 31st, 1921, received from J. V. Davies, M. Am. Soc. C. E., was presented, reciting the history and status of this matter at the present time.

Acceptances were reported from all the members appointed at the Board meeting of October 11th, 1921, on the Research Committee and from representatives of the Society on the Advisory Committee on Civil Engineering of the Division of Engineering of the National Research Council.

On motion of Past-President Talbot, duly seconded, and carried, the old Committee on Research, appointed by the Board in August, 1920, composed of the Chairman of the Special Committees on Soils, Stresses in Railroad Track, and on Bridge Design, was discharged.

Advisory Board to U. S. Bureaus of Mines and Standards

It was reported that in accordance with authority granted* at the meeting of the Executive Committee held December 20th, 1921, President Webster had appointed T. R. Lawson, M. Am. Soc. C. E., who has accepted, to represent the Society as a member of the Advisory Board to the U. S. Bureau of Mines and the U. S. Bureau of Standards in conducting investigations on "the breakage and heat treatment of rock drill steels and other steels and alloys subjected to similar impact stresses".

On motion of Director Humphrey, duly seconded, and unanimously carried, this appointment was confirmed.

Culvert Pipe Specifications

A progress report was presented from Messrs. T. L. D. Hadwen and George H. Tinker, the Society's representatives on Culvert Pipe Specifications, received under date of December 21st, 1921, with an Appendix giving account of experiments of the Engineering Experiment Station, Iowa State College.

On motion of Past-President Talbot, duly seconded, and carried, this report was received and referred to the Publication Committee.

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* See p. 223.

Advisory Council of Board of Surveys and Maps

A report for 1921 was presented from J. K. Finch, Assoc. M. Am. Soc. C. E., the Society's representative on the Advisory Council of the Board of Surveys and Maps.

On motion of Past-President Talbot, duly seconded, and carried, this report was received and referred to the Publication Committee.

Award of Medals and Prizes

The following report of the Committee on the Award of Medals and Prizes for the Year 1921, was received:

"December 17, 1921.

"Mr. George S. Webster,
President, American Society of Civil Engineers,
33 West Thirty-ninth Street,
New York City, N. Y.

"Sir.—Under date of May 23d, 1921, Acting Secretary, Elbert M. Chandler, notified the subscribers thereto, namely, J. C. Nagle, H. L. Haehl and W. Easby, Jr., that you had appointed them members of the Committee on Prizes for the year 1921. For reasons of geographical location it has not been possible for the members of this committee to meet in personal consultation but by personal correspondence we have exchanged opinions regarding our estimates of the merits of the papers presented to us for consideration and as a result we submit the following recommendations:

"1. That no award of the Norman Medal be made for the year 1921.

"2. That Fred A. Noetzli, Assoc. M. Am. Soc. C. E., be awarded the James J. Croes Medal, for paper on 'Gravity and Arch Action in Curved Dams'. Vol. LXXXIV, p. 1.

"3. That Ernest E. Howard, M. Am. Soc. C. E., be awarded the Thomas Fitch Rowland Prize, for paper on 'Vertical Lift Bridges'. Vol. LXXXIV, p. 580.

"4. That W. C. Curd, M. Am. Soc. C. E., be awarded the James Laurie Prize, for paper on 'Bank Protection and Restoration; A Problem in Sedimentation'. Vol. LXXXIV, p. 303.

"5. That no award of the Arthur M. Wellington Prize be made for the year 1921 in the absence of specific rules formulated by the Board of Direction. Your Committee is of the opinion that neither of the two papers on transportation problems, which were submitted to the Committee for consideration, were of an unusually high order. However, should the rules of the Board of Direction provide that this prize be awarded for the 'most meritorious paper of the year' on the subject of transportation we would then recommend that this prize be awarded to J. A. L. Waddell, M. Am. Soc. C. E., for paper on 'Creeping of Railroad Rails'. Vol. LXXXIV, p. 361.

"6. That L. Standish Hall, Jun. Am. Soc. C. E.,* be awarded the Collingwood Prize for Juniors, for paper on 'The Probable Variations in Yearly Run-off as Determined from a Study of California Streams'. Vol. LXXXIV, p. 191.

"Respectfully submitted,

"J. C. Nagle
"H. L. Haehl
"Wm. Easby, Jr.,
"Committee on Prizes."

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* Now Assoc. M. Am. Soc. C. E.

On motion of Director Humphrey, seconded by Past-President Talbot, and carried, this report was received, and the recommendations contained therein were adopted. (There is to be no award of the Wellington Prize for 1921).

Resolution Changing Number of Directors to Accord with New Constitution

The Acting Secretary reported the necessity for the passage of a resolution before the new Officers are elected at the 1922 Annual Meeting, changing the number of Directors to accord with the new Constitution.

A letter of October 22d, 1921, from Messrs. Parker and Aaron,* Counsel for the Society called attention to the fact that the mere adoption of the amendment to the Constitution is not of itself sufficient to change the legal number of Directors; but that it would be necessary for a resolution to be presented at the Annual Meeting, by which the meeting shall determine to change the number of Directors to that provided in the revised Constitution.

As directed, the Acting Secretary secured from Counsel, the following proposed resolutions:

"*Resolved,* That the American Society of Civil Engineers, a membership corporation, organized under the laws of the State of New York, does, pursuant to the provisions of Section 14 of Chapter 40 of the Laws of 1909, as amended by Chapter 577 of the laws of 1921, hereby determine to change the number of its directors as follows, to wit:

"The Board of Direction, in which the government of the Society shall be vested and who shall constitute the Trustees provided for by the laws under which the Society is organized, shall hereafter be twenty-five (25) in number and shall consist of and be constituted of the President, the four (4) Vice-Presidents, eighteen (18) Directors, and the two (2) latest living Past-Presidents continuing to be members of the Society.

"*Further Resolved,* That the President and Secretary of this meeting be authorized and directed to sign, acknowledge and file a certificate specifying the foregoing determination and the number of Directors."

Director Hudson suggested that this matter should be discussed when there were more Directors present, which was seconded by Director Humphrey, and the matter was postponed until later.

On motion of Director Hudson, the meeting adjourned at 10 P. M., to meet at 10 A. M., January 17th, 1922.

January 17th, 1922.—The Board reconvened at 10 A. M.; President George S. Webster in the chair; Elbert M. Chandler, Acting Secretary; and present also Messrs. Alvord, Anderson, Beahan, Brown, Clark, Cummings (came in at 10:20 A. M.), Curtis, Davis, Greene, Grunsky, Henny, Herschel, Hogan, Hovey, Hoyt, Hudson, Humphrey, Langthorn (came in at 11:05 A. M.), Marston, Pegram, Stuart (came in at 10:30 A. M.), Talbot, and Wall.

The Acting Secretary again presented the proposed resolution prepared by Counsel, changing the number of Directors to accord with the new Constitution.

This matter was discussed by Messrs. Anderson, Brown, Curtis, Davis, Grunsky, Herschel, Hogan, Hoyt, Hudson, Humphrey, Marston, and Talbot.

* See p. 212.

Director Grunsky moved that the Board authorize the presentation of these resolutions to the Annual Meeting. This motion was seconded by Treasurer Hovey.

On motion of Director Clark, seconded by Director Greene, and carried, the Acting Secretary was requested to ask a representative from Parker and Aaron to appear before the Board and answer any necessary questions.

Subsequently, at 11:25 A. M., Mr. Charles A. Baker appeared before the Board and answered the various questions put to him by Messrs. Grunsky, Talbot, and Webster, after which a rising vote of thanks was tendered Mr. Baker, who withdrew.

Director Grunsky's motion was then carried unanimously.

Charter from Federal Government

Past-President Herschel addressed the Board as to the desirability of the Society securing a Federal Charter from the National Government in Washington, and after discussion by Messrs. Marston and Talbot, on motion of the former, seconded by Director Beahan, and carried, this matter was referred to the incoming Board.

Authority Granted to Rent Past-Presidents' Room

The Acting Secretary reported, as requested by the Executive Committee, concerning the portraits of Past-Presidents now in the Past-Presidents' Room and the possibility of renting this room was discussed by Messrs. Davis, Grunsky, and Humphrey.

On motion of Director Humphrey, seconded by Director Beahan, the following resolution was adopted:

"*Resolved:* That the Board of Direction authorizes release of Room 1615, generally known as the Past-Presidents' Room, on the sixteenth floor of Engineering Societies Building, to United Engineering Society for the use of whomever* is assigned to it, subject to the following reservations:

"First, That the usual Associates' agreement be entered into giving this Society the right to recall the use of this space upon 30 days' written notice.

"Second, That the American Society of Civil Engineers be credited with the entire amount of rent paid which is estimated to be $2 100 per year."

No action was taken concerning the disposition of the portraits of the Past-Presidents.

Proposed Congress in Rio de Janeiro, Brazil, in September, 1922

The possibility of holding a Congress in Rio de Janeiro, Brazil, in September, 1922, was verbally presented by the Acting Secretary, communications having been received relative thereto, from Verne LeRoy Havens, M. Am. Soc. C. E., who states that it is believed that an international conference of engineers from all the American countries should be held very soon, to discuss the practical problems of conservation and utilization of natural resources and to establish a closer contact between those persons engaged with the technical industrial problems of the economic advancement of all the Americas, and it is suggested that the most appropriate time and place would be in

* Subsequently assigned to the American Engineering Standards Committee by the United Engineering Society.

Rio de Janeiro, Brazil, during September, 1922, contemporaneously with the first centennial celebration of Brazilian Independence, and that a list of ten subjects has been tentatively prepared. Mr. Havens asks whether the Society approves of the plan suggested for such International Engineering Congress and whether assistance and co-operation might be expected.

On motion of Director Alvord, seconded by Director Humphrey, and carried, this matter was referred to the incoming Board.

International Engineering Congress, Philadelphia, Pa., in 1926

A letter, dated December 21st, 1921, was presented from Ralph Modjeski, M. Am. Soc. C. E., inviting this Society to appoint two representatives to represent it at a meeting with representatives of the other three Founder Societies, the American Society for Testing Materials, and the Engineers' Club of Philadelphia, to be held on February 9th, 1922, at 12:30 P. M., at the Engineers' Club in Philadelphia, to formulate plans for an International Engineering Congress to be held in Philadelphia in 1926.

Director Hogan moved that this matter be referred to the incoming Board, which motion was seconded.

Director Humphrey moved that Director Hogan's motion be laid on the table, which was carried by an "aye" and "no" vote.

Director Humphrey then moved:

"That the President of the present Board appoint two delegates to attend the meeting as requested."

This motion was seconded by Treasurer Hovey.

Vice-President Cummings suggested an amendment, which Director Humphrey accepted, and stated his revised motion to be:

"That the present President of the Society, and one other member, to be appointed by him, represent the Society at that time."

Vice-President Cummings seconded this motion, and it was duly carried.

Study of Flood Prevention

Letters of December 28th, 1921, and January 7th, 1922, were presented from Edward Stuart, Assoc. M. Am. Soc. C. E., Director of Disaster Relief Service of the American Red Cross, Washington, D. C., as to co-operation by this Society in flood prevention work, Mr. Stuart having presented a report to his Executive Committee suggesting that a temporary committee be appointed to consider some of the questions involved.

Discussion was participated in by Messrs. Anderson, Curtis, Davis, Henny, Hoyt, Humphrey, Marston, and Talbot.

Director Hoyt moved: "That we appoint a representative to meet with them."

This motion was seconded by Director Anderson.

Director Humphrey offered an amendment: "That Mr. Davis be designated as the representative to attend the meeting," which amendment was accepted by Director Hoyt, and duly carried.

Committee on Welded Joints

It was reported that an invitation to this Society to appoint two representatives on a Committee on Welded Joints was presented to this Board at its October meeting, and the action taken was to refer the matter to L. H. Davis, M. Am. Soc. C. E., the Society's representative on the Board of Directors of the American Welding Society.

Mr. Davis' letter of December 31st, 1921, was presented, suggesting the appointment of E. M. T. Ryder, M. Am. Soc. C. E., and one of the following four other members of the Rail Joints Committee, of which Mr. Ryder is Vice-Chairman: Howard H. George, C. S. Kimball, H. M. Steward, and G. L. Wilson.

On motion of Past-President Talbot, duly seconded, and carried, Mr. E. M. T. Ryder was appointed as one of the Society's representatives on the Committee on Welded Joints, and the President was empowered to appoint the other representative.

President Webster subsequently appointed Howard H. George, M. Am. Soc. C. E., as the other representative.

Joint Committee Suggested to Study Housing Problem

The following extract from the January 12th, 1922, issue of *Engineering News-Record* was reported from an article concerning the Society meetings of January 4th and 5th, 1922, when the "National Housing Problem" was discussed:

"Mr. Ham proposed that the American Society of Civil Engineers, the American Institute of Architects, the American Society of Mechanical Engineers, and various financial and other institutions should appoint a joint committee to study the whole housing problem and that the American Society of Civil Engineers should employ a high-class man as director of the study."

On motion of Director Humphrey, duly seconded and carried, this matter was referred to the Committee on Special Committees of the incoming Board.

Sectional Committee for Unification of Existing and Proposed Specifications for Steel Railway Bridges

A letter of January 12th, 1922, was presented, addressed to this Society and the American Railway Engineering Association, from Secretary Agnew, of the American Engineering Standards Committee, from which the following is a quotation:

Voted: That the Secretary be instructed to revive the question of the formation of a sectional committee for specifications for Steel Railway Bridges, under the joint sponsorship of the American Society of Civil Engineers and the American Railway Engineering Association."

"The American Engineering Standards Committee will be much gratified if your associations decide to accept the responsibility for sponsorship and the organization of a representative sectional committee for the unification of existing and proposed specifications for Steel Railway Bridges."

The matter was discussed by Messrs. Hudson and Talbot.

On motion of Director Hogan, seconded by Director Brown, and carried, this matter was referred to the Committee on Special Committees of the incoming Board.

Abbreviations in Engineering Practice

A letter of January 13th, 1922, was presented from Secretary Agnew, of the American Engineering Standards Committee, stating that sometime within the next month or two there will be a Conference on the Unification of Abbreviations Used in Engineering Practice. Dr. Agnew states this Society may wish to decide on its representative. A formal invitation will be received in the near future, but this advance notice is given on account of the Board meeting being held now.

On motion of Past-President Talbot, duly seconded and carried, the President was authorized to appoint such representative.

New Member on Bridge Committee

It was reported that the Special Committee to Consider and Recommend for Adoption a Specification for Bridge Design and Construction, had asked that Victor H. Cochrane, M. Am. Soc. C. E., be appointed to take the place made vacant by the resignation of Past-President George H. Pegram.

Messrs. Hudson, Humphrey, and Talbot spoke, and on motion of Past-President Curtis, seconded by Director Clark, and carried, Mr. Cochrane was appointed as a member of the Special Committee on Bridge Design and Construction.

Rules for Special Committees

The Acting Secretary brought up the matter of rules for Special Committees, explaining that the rules as printed in the Year Book in one place provide that "all bills submitted by a Special Committee shall be approved by its Chairman and Secretary", and, subsequently, under the heading, "Expenses", it is provided that: "Extraordinary expenses, such as purchase of instruments, salaries of special employees and traveling expenses, must be specifically authorized and approved by the Chairman of the Committee concerned". It seemed therefore that the procedure in this matter might be simplified by a rule which stated that all bills shall be approved by the Chairman.

A motion to this effect was made by Director Humphrey, and was duly seconded and carried.

Mileage for Committees

The Acting Secretary suggested that the Board adopt a rule that only actual traveling expenses, as submitted, be paid to members of Committees in attendance at meetings, and that such payment should never exceed regular mileage rate, and, on motion of Past-President Herschel, seconded by Director Brown, this was adopted.

Suggested Amendment to By-Laws of United Engineering Society

The following letter dated December 21st, 1921, from Secretary Flinn, of the United Engineering Society, was reported:

"For the efficient conduct of the business of United Engineering Society, it is highly desirable to have the services of able men so situated that they can give the necessary time to their duties. It is also an advantage to have continuity in service so as to benefit by the experience gained. The number

of men who can satisfy the foregoing specifications is naturally limited. In affect, their number could be increased by taking advantage of the fact that some of these men are members of more than one Founder Society. By-Law 18 of United Engineering Society now reads:

"'A Trustee shall not be eligible for more than two terms consecutively.'

"In an opinion dated December 7th, 1921, given by Parker and Aaron, Counsel to the American Institute of Electrical Engineers, a man having served two consecutive terms as Trustee of one Founder Society cannot be elected for the next following term as a Trustee to represent another Founder Society. Two of the Founder Societies have this year made such choices of Trustee. To meet this situation, Parker and Aaron, who are also Counsel to United Engineering Society, have suggested to the American Institute of Electrical Engineers that By-Law 18 be amended to read:

"'A Trustee shall not be eligible as <u>a representative of the same Founder Society</u> for more than two terms consecutively." [Words underscored are new.]

"Before voting on the amendment suggested, the Trustees of United Engineering Society desire to be informed of its acceptability to the Founder Societies.

"The suggested amendment will be proposed at the meeting of United Engineering Society, December 22d, 1921, and, in ordinary course, will be presented for vote at the meeting January 26th, 1922.

"If convenient, an expression of opinion from the Founder Societies is desired before the latter date, since at that time the Trustees who have been elected by a second Founder Society after having served two terms for another Founder Society, will assume office."

On motion of Past-President Herschel, seconded by Director Beahan and carried, approval was given to this proposed amendment.

The following new By-Law of the United Engineering Society was reported for the information of the Board, the approval of the governing boards of the Founder Societies not being required:

"III*a*. Memorials may be accepted by the Trustees and placed in Engineering Societies Building on the following conditions: Each proposal shall be thoroughly considered from all points of view, including the nature of the proposed memorial and its artistic appropriateness; the memorial, upon acceptance, shall become the property of United Engineering Society and thereafter the Society may change the location of the memorial or take such other action with reference thereto as may, in its judgment, be advisable; no memorial shall be placed in the building in honor of any person within five years after his decease unless his death shall have been directly due to a notable service to our country or to the profession of engineering."

Proposed Amendments to Constitution of American Engineering Standards Committee

Two proposed amendments to the Constitution of the American Engineering Standards Committee were reported, on which favorable action was recommended by the Committee.

On motion of Past-President Pegram, duly seconded, and carried, these amendments were approved.

Local Sections

A letter, dated October 13th, 1921, was presented from Paul C. Gauger, Secretary of the Northwestern Section of this Society, forwarding the proposed amended Constitution of the Northwestern Section, which he sub-

mitted for the approval of the Parent Society. It was reported that this amended Constitution is in correct form and does not materially change the old Constitution approved November 4th, 1914.

On motion of Director Hudson, duly seconded and carried, the amended Constitution of the Northwestern Section was approved.

A letter dated December 30th, 1921, was presented from George N. Schoonmaker, Assoc. M. Am. Soc. C. E., forwarding the proposed Constitution of the Toledo Section of this Society, which, it was reported, was in correct form.

On motion of Director Grunsky, seconded by Director Anderson and carried, the Constitution of the Toledo Section was approved.

The Acting Secretary reported the following and asked for a definite ruling as to continuation of the practice:

That at the meeting of the Board of Direction held November 9th, 1920, a resolution was adopted that the expense of sending out notices of the meetings of the New York Section to the entire resident membership of this Society should be temporarily defrayed by the Society. To the time of the formation of the New York Section, it was the custom of this Society to hold semi-monthly meetings. Arrangements were made whereby the New York Section took over the second of these meetings and paid all the expenses therefor. The Section membership at the present time is approximately 400. The Section invites all resident members of the Society, whether members of the New York Section or not, to its meetings. The expense of these invitations averages $30 per month.

Vice-President Cummings moved the approval of continuation of the practice, which motion was seconded by Director Hogan.

Director Humphrey offered as an amendment, which was carried:

"That the matter be referred to the incoming Board at the time of consideration of allotting dues to Local Sections."

Representatives on Engineering Societies' Library Board

Vice-President Cummings addressed the Board regarding the desirability of having the terms of office of the representatives of the Society on the Library Board of the Engineering Societies' Library, expire at the time of the Annual Meeting of the Society instead of on December 31st of each year. This would allow the representatives to attend the Annual Meeting of the Library Board which is held each year just preceding the Annual Meeting of this Society.

On motion of Vice-President Cummings, duly seconded and carried, this was ordered.

Resolution of Thanks to Standing Committees

The following resolution was adopted:

"*Resolved*, That the Board of Direction of the American Society of Civil Engineers hereby expresses its thanks and appreciation to the individual members of its Standing Committees for their work on such Committees and is especially grateful to the Chairmen thereof."

The following matters were reported for the information of the Board:

That although both Messrs. R. O. Wynne-Roberts and H. E. Riggs accepted their appointments to represent the Society at the December Meeting of the American Association for the Advancement of Science, they could not attend the meeting. (The By-laws of the Association require that representatives shall be selected from members and Mr. Wynne-Roberts was not a member of the Association and the time was too short to appoint some one else. Mr. Riggs was reinstated in the Association.)

That William D. Uhler, M. Am. Soc. C. E., had been appointed as the representative of the Society on the Committee to Further Co-Operate with the U. S. Department of Commerce and Carry Out the Recommendations of the Conference held in Washington, D. C., November 15th, 1921, on Consideration of Possibility of the Elimination of Excess Variety and Style in Paving Brick.

That the Executive Committee meeting of December 20th, 1921, authorized President Webster to appoint Tellers to canvass the Ballot for Officers for 1922, starting at 9 A. M., January 18th, 1922, and that, subsequently, he had appointed Messrs. W. G. Grove, Chairman, C. S. Bilyeu, A. W. Carpenter, Ralph H. Chambers, C. E. Conover, W. H. Chorlton, R. de Charms, Jr., Myron E. Fuller, R. R. Graham, H. P. Hammond, Nathan C. Johnson, George Perrine, F. W. Perry, D. H. Sawyer, George L. Sawyer, F. LeRoy Stearns, all of whom have accepted.

That a radiogram was received from Luigi Luiggi, M., Am. Soc. C. E., on January 11th, 1922, accepting Honorary Membership in the Society, to which grade he was elected October 10th, 1921.

That the January *Proceedings* would contain a subject catalog of the books and pamphlets in the Engineering Societies Library on "Highway Engineering."

Vice-President Cummings addressed the Board concerning the importance of cataloguing the Library.

Suggested Change *Re* Compounding of Dues

The following letter, dated January 13th, 1922, from Lewis D. Rights, M. Am. Soc. C. E., was reported:

"I find that I have paid dues to the American Society of Civil Engineers for a period of twenty years. If I continue paying for fifteen years more I will be exempt.

"I would like to compound my future dues, but it would not pay me to do so if I was compelled to turn over a single payment of $325.

"It seems as if there should be some provision for proportionate payment in the compounding of dues. In my case, three-sevenths of the total of $325, or about $140, would give the Society the proper proportion.

"I am writing to suggest that steps be taken to bring about a change in the Constitution to cover this point. As the member compounding his dues takes all the chances of death or withdrawal from the Society, any move of this sort would be of financial benefit to the Society. Our curve of compensation indicates that young men entering the Society cannot well compound their dues, but might be able to do so sometime in the middle of their careers."

On motion of Director Hogan, seconded by Director Beahan, and carried, this matter was referred to the Executive Committee to report to the Board.

On motion of Director Humphrey, seconded by Director Beahan, recess for luncheon was taken at 12:40 P. M., until 2 P. M.

The Board reconvened at 1:45 P. M., with the same attendance as in the forenoon, except that Director Darrow was present and Messrs. Grunsky, Henny, and Marston were absent.

A letter dated December 30th, 1921, from Mr. F. G. Carrel, was presented concerning the necessity for watching carefully to see that nothing of a commercial prejudice develops in Joint Committee work, especially referring to the Concrete Committee.

On motion of Past-President Talbot, this matter was referred to the Publication Committee.

Monthly Society Meetings

The proposed amendment to omit that part of Section 1 of Article VI of the By-Laws requiring that a Society meeting be held on the first Wednesday of each month, was discussed by Messrs. Anderson, Hogan, Hudson, Humphrey, and Talbot.

Director Humphrey moved that the amendment be adopted. This motion was seconded by Director Beahan.

A roll-call was taken on the motion as follows:

Ayes (9): Anderson, Beahan, Brown, Davis, Greene, Hoyt, Humphrey, Wall, and Webster.

Noes (13): Alvord, Clark, Cummings, Curtis, Darrow, Herschel, Hogan, Hovey, Hudson, Langthorn, Pegram, Stuart, and Talbot.

The President declared that, as the motion had failed to receive a two-thirds vote, as required, the amendment therefore failed.

Pollution of Streams by Industries

A letter, dated January 13th, 1922, from Charles Haydock, Assoc. M. Am. Soc. C. E., addressed to President Webster, was presented recommending to the Board that the subject of pollution of streams by industries be carefully considered "and if it is found to be a proper province of the Association that a suitable resolution be adopted recommending that a complete investigation of the cause, extent, and effect of pollution of waters by industries be made, that methods of mitigating such evils be investigated, and that existing legislation be reviewed in order to determine what, if any, further legislation is required to cope with the situation, such resolution to be forwarded to Washington in order that the same may receive proper consideration by the Senate, the House of Representatives, the Secretary of War and the Secretary of Commerce".

On motion of Past-President Talbot, seconded by Director Beahan and carried, this matter was referred to the Committee on Special Committees of the incoming Board, which action was subsequently confirmed by the new Board.

Licensing of Engineers

Chairman Humphrey, of the Committee on Licensing Engineers, presented the following report:

"To the Board of Direction,
Am. Soc. C. E.

"Gentlemen.—Your Committee has given consideration to the matter of licensing engineers and finds itself not quite ready to present a report at this time and asks that it be continued until the next meeting of the Board [in April].

Respectfully submitted,

"A. M. Hunt,
"Anson Marston,
"Baxter L. Brown,
"Willard Beahan,
"Richard L. Humphrey,
"Chairman."

Discussion was participated in by Messrs. Herschel, Hudson, and Humphrey.

On motion of Past-President Curtis, seconded by Director Beahan, and carried, this report was accepted.

The matter of the cost of mimeographing hearings held by the Committee on Licensing Engineers during the last few months, was discussed by Messrs. Alvord, Curtis, Hogan, and Humphrey.

Director Hogan moved

"That the question of mineographing these minutes be postponed until we receive the report of the Committee."

Director Humphrey moved that it be laid on the table, which motion was seconded by Director Beahan, and was lost by show of hands resulting in 8 "ayes" and 12 "noes".

Director Hogan's original motion was then carried by an "aye" and "no" vote.

Districts and Zones

The matter of fixing the Districts and Zones as required by the new Constitution was taken up, copies of the following report of the Committee being distributed:

"To the Board of Direction,
Am. Soc. C. E.

"Gentlemen.—Your Committee on Zones and Districts presents herewith its recommended distribution of the Corporate Membership of the Society as of January 1st, 1922, into Districts and Zones as provided by the Constitution and By-Laws.

Respectfully submitted,

"Willard Beahan,
"Anson Marston,
"John C. Hoyt,
"Carleton Greene,
"Richard L. Humphrey,
"Chairman."

Proposed Distribution of Corporate Members of the Society, as of January 1st, 1922.

District 1.—	Connecticut (within 50 miles New York City P. O.)	17		
	New Jersey (within 50 miles New York City P. O)	295		
	New York (within 50 miles New York City P. O.)	1 294	1 606	
	Members outside of North America		575	2 181
District 2.—	Connecticut (outside of District 1)	117		
	Maine	36		
	Massachusetts	417		
	New Hampshire	27		
	Rhode Island	43		
	Vermont	14	654	
	New Brunswick, Canada		4	
	Nova Scotia, Canada		1	659
District 3.—	New York (outside District 1)		486	
	Quebec, Canada		58	544
District 4.—	New Jersey (outside of District 1)	68		
	Delaware	37		
	Pennsylvania (East of W. Long. 78°)	496	601	601
District 5.—	District of Columbia	243		
	Maryland	175		
	Virginia	142	560	560
District 6.—	Pennsylvania (West of W. Long. 78°)	327		
	West Virginia	89	416	
	Ontario, Canada		58	474
District 7.—	Iowa	112		
	Michigan	211		
	Minnesota	146		
	North Dakota	11		
	South Dakota	15		
	Wisconsin	74	569	
	Manitoba, Canada		7	576
District 8.—	Illinois	532	532	532
District 9.—	Indiana	81		
	Kentucky	52		
	Ohio	434	567	567
District 10.—	Alabama	59		
	Florida	80		
	Georgia	79		
	Mississippi	31		
	North Carolina	98		
	South Carolina	47		
	Tennessee	92	486	486

District 11.—	Arizona	45		
	California (South of N. Lat. 36° 30′)	229		
	Colorado	109		
	New Mexico	17		
	Utah	49		
	Wyoming	25	474	474
District 12.—	Idaho	42		
	Montana	70		
	Oregon	125		
	Washington	198	435	
	Alaska		5	
	Alberta, Canada		13	
	British Columbia, Canada		18	
	Saskatchewan, Canada		2	473
District 13.—	California (North of N. Lat. 36° 30′)	487		
	Nevada	11	498	498
District 14.—	Kansas	91		
	Missouri	296		
	Nebraska	79	466	466
District 15.—	Arkansas	68		
	Louisiana	86		
	Oklahoma	66		
	Texas	276	496	
	Mexico		40	536

	Resident in United States.	All Members.
Zone 1.—Districts Nos. 1, 2, 3	2 746	3 384
Zone 2.—Districts Nos. 4, 5, 6, 10	2 063	2 121
Zone 3.—Districts Nos. 7, 8, 9, 14	2 118	2 125
Zone 4.—Districts Nos. 11, 12, 13, 15	1 919	1 997

Year for Election of Vice-Presidents:	
Zones 2 and 3	1923
Zones 1 and 4	1924
Year for Election of Directors:	
Districts Nos. 3, 5, 7, 8, 9, 12, 15	1923
Districts Nos. 1 (2), 4, 11, 14	1924
Districts Nos. 1 (2), 2, 6, 10, 13	1925

This matter was discussed by Messrs. Anderson, Brown, Cummings, Curtis, Davis, Grunsky, Henny, Hogan, Hoyt, Humphrey, Marston, and Talbot.

Director Beahan moved that the report of the Committee be received and adopted.

Director Hogan moved as an amendment that this matter be referred to the incoming Board for action, which was seconded by Past-President Pegram, and carried by show of hands resulting in 12 "ayes" and 9 "noes".

(Directors Hogan and Hoyt both suggested that copies of the report be furnished each of the new members of the incoming Board and this was done.)

Benevolent Fund

Director Anderson made a verbal progress report of his Committee to Investigate and Report in Regard to the Desirability of Creating a Benevolent Fund.

On motion of Director Brown, seconded by Treasurer Hovey, and carried, the Committee was continued as at present constituted.

Technical Activities

The report of the Committee Considering the Report of the Committee to Promote the Technical Interests and Activities of the Society, was taken up, and Chairman Talbot presented the following report:

"January 17, 1922.

"To the Board of Direction
of the American Society of Civil Engineers:

"The Committee to whom was referred the report of 'The Committee to Promote the Technical Interests and Activities of the Society,' together with the whole matter of the method of promoting the technical activities of the Society, makes the following recommendations:

"1.—That a temporary special committee on Technical Activities be appointed at once and that the by-laws be amended as soon as possible so as to create a standing committee on Technical Activities and Publications.

"2.—That the special temporary committee on Technical Activities consist of the Committee on Publications together with other members, and that the new standing Committee on Technical Activities and Publications replace the Committee on Publications. The Committee should consist mainly of members of the Board of Direction.

"3.—That the Committee on Technical Activities be charged with the promotion of the technical interests and the stimulation of the activities of the Society in technical professional matters. The duties of the proposed Committee on Technical Activities and Publications should include those of the special Committee on Technical Activities and the Committee on Publications. As the present by-laws give the Committee on Publications the supervision over publications only, the revision may well provide that the new committee shall have supervision of technical meetings also.

"4.—That in addition to the regular membership of the Committee on Technical Activities and Publications advisory sub-committees be appointed. These sub-committees should cover the principal branches of the civil engineering field. Membership shall not be confined to membership on the Board of Direction. Sub-committee members may well be selected in various engineering centers; it is expected that they will act as liaison members who will encourage contact with local sections and with members in their communities. Appointment on sub-committees will be made by the main Committee after consultation with local sections.

"5.—That it be recognized that the Society may with profit greatly enlarge its activities through technical committees in the various branches of the Society's field and that the Committee on Technical Activities and Publications be urged to take steps to develop more fully this agency for technical work.

"6.—That a spring professional meeting be held in the spring of 1922 at some point away from New York City with the thought that experience may show the wisdom of adopting the policy of holding spring and fall professional meetings in addition to the Annual Meeting and the Annual Convention. A trial of this plan may be made without changing the Constitution.

"7.—That the importance of giving further attention to the younger members of the Society be recognized. To further this end it is recommended:

"(*a*) That representation on programs be provided for Juniors and for the younger members with a view of encouraging their activity in participation in Society affairs and that an effort be made to include such representation on the program of the proposed Spring professional meeting.

"(*b*) That correspondence be taken up by the Secretary with the Student Chapters with a view of assisting the Chapters in arranging for addresses to be given before the Chapters by members of the Society.

"(*c*) That the Committee on Technical Activities and Publications be instructed to give early attention to other measures that will promote the interests of the younger members of the Society.

"If these recommendations meet with the approval of the Board of Direction proposals for a change in the By-Laws will be made.

"Of the recommendations of the Committee to Promote the Technical Interests of the Society it is recommended that the one urging that the Local Sections provide for themselves a program of technical activities be referred to the Local Sections. It would appear that the conditions surrounding the Local Sections are so diverse that a common policy in this matter would not be generally acceptable. It is also recommended that the Local Sections be urged to bring to the attention of the Committee on Technical Activities and Publications any matters or materials which it may be thought would be of value to the Society.

"The Committee further recommends that the request of the Committee to Promote the Technical Interests of the Society to be discharged be granted and that the Board of Direction express appreciation of the work of the Committee.

"Respectfully submitted,

"A. N. TALBOT,
"JOHN C. HOYT,
"RICHARD L. HUMPHREY,
"Committee."

This matter was discussed by Messrs. Brown, Cummings, Herschel, Hogan, Hoyt, Humphrey, and Talbot.

Vice-President Cummings moved that the report of the Committee be accepted and adopted by this Board as a whole and a vote of thanks tendered this Committee.

This motion was seconded by Director Beahan and carried unanimously.

At 5:10 P. M. the Board recessed to meet as a Membership Committee.

Adjourned at 6 P. M.

January 18th, 1922.—The Board met at 4:15 P. M., at the Headquarters of the Society; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present also Messrs. Anderson, Brown, Chester, Curtis, Darrow, Davis, Dyer, Greene, Grunsky, Henny, Hogan, Holland, Hoyt, Huber, Hudson, Humphrey, Marston, O'Connor (came in at 4:40 P. M.) Pegram, Ridgway, Talbot, Wall, Webster, Winsor, and Yates.

Director Hudson suggested sustaining the action of the outgoing Board in postponing the question of the mimeographing of its Minutes until the Report of the Committee on Licensing Engineers is received. Messrs. Curtis, Davis, and Grunsky discussed the question.

On motion of Director Hogan, recess was taken at 5:55 P. M., until 10 A. M., January 19th, 1922.

January 19th, 1922.—The Board reconvened at 10 A. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present also Messrs. Anderson, Brown, Chester, Curtis, Darrow (came in at 10:45 A. M.), Dyer, Greene, Grunsky, Henny, Hogan, Holland, Hoyt, Huber (came in at 10:50 A. M.), Hudson, Marston, Ridgway, Talbot, Wall, Webster, Winsor, and Yates.

Local Sections

The Acting Secretary presented for consideration a tentative resolution covering the question of disbursements to be made under the item of Local Sections, which motion was then offered by Director Hudson and seconded by Director Brown.

Messrs. Anderson, Brown, Chester, Greene, Holland, Hoyt, Hudson, Wall, Webster, and Winsor discussed the matter and, after suggestions and amendment, the following resolution was unanimously adopted:

"*Voted:* That the Acting Secretary is authorized to communicate with each Local Section stating that the Board of Direction is prepared to pay to the Sections for operating expenses on the basis of $1 per member of the Section as of January 1st, 1922. This will be on the basis of members who are in good standing with the Parent Society and the Local Section. Each Section will be required to submit a list of its members as of that date signed by the Secretary of the Section, and the Treasurer is authorized to disburse to the Sections in accordance with the above provisions."

It was reported that the outgoing Board had referred to the incoming Board the question of the continuation of payment by the Society for postal card notices of the meetings of the New York Section to be considered in connection with the above.

After discussion, participated in by Messrs. Anderson, Chester, Hogan, Hoyt, Hudson, Ridgway, and Wall, the following motion made by Director Hoyt and seconded by Director Anderson, was carried:

"That the Secretary be authorized to pay for these postal card notices."

Powers of Executive Committee

The following motion was offered by Director Brown, seconded by Director Chester, and unanimously carried:

"*Voted:* That the Board of Direction hereby empowers the Executive Committee to act between meetings of the Board in all routine matters and those pertaining to Society affairs, which cannot consistently be deferred until the next Board meeting. This does not include power to amend the By-Laws, elect or expel members, nor to fill vacancies on the Board of Direction."

1922 Annual Convention

The time and place for holding the 1922 Convention was then considered, the recommendation of the outgoing Board to this Board being that the Convention be held in the White Mountains.

Discussion was participated in by Messrs. Anderson, Chester, Curtis, Holland, Hoyt, Huber, Hudson, Webster, and Winsor.

On motion of Director Chester, seconded by Past-President Curtis, and carried, it was decided to hold the 1922 Annual Convention in the mountain

district of New England, and the President is to appoint a committee with power to select a definite place and make all the necessary arrangements, etc.

On motion of Director Hoyt, seconded by Director Chester, and carried, the fixing of the date for the Convention was also left to the committee to be appointed by the President.

Dates of Future Board Meetings

The matter of dates for holding future Board meetings was discussed by Messrs. Anderson, Brown, Chester, Curtis, Hogan, Hoyt, Huber, Hudson, Webster, and Winsor, and after several tentative motions and amendments, the following dates were adopted:

April 3d, 1922, Dayton, Ohio...........	(To be followed by the Spring Society Meeting on April 5th and 6th, 1922, in Dayton when "National Flood Problems" will be discussed).
May 8th, 1922, New York City.........	(Intermediate Board Meeting).
June	(At the time and place of the Annual Convention, which are to be determined by a committee to be appointed by the President).
September 11th, 1922, New York City..	(Intermediate Board Meeting).
October	(On the Pacific Coast, at the time and place of the Fall Society Meeting to be held there when a Symposium on Water Power will be had, the date for which is to be determined after consultation with the San Francisco Section. It is understood the Board meeting date will be as near October 16th and 17th, 1922, as possible).
December 4th, 1922, New York City....	(Intermediate Board Meeting).
January 15th, 1923, New York City.....	(Last meeting).

Federal Charter for the Society

It was decided to postpone consideration of the matter of a Federal Charter for the Society which had been referred by the outgoing Board to this Board.

Districts and Zones

The report of the Committee on Districts and Zones,* was then taken up, and the matter was discussed by Messrs. Anderson, Brown, Chester, Curtis, Darrow, Dyer, Greene, Grunsky, Hogan, Hoyt, Holland, Hudson, Marston, Talbot, Wall, and Webster.

Director Brown moved to take up the matter of Districts first, which motion was seconded by Director Anderson, and carried.

Vice-President Wall moved:

"That we adopt the Districts as laid out by the Committee with the change suggested by Director Hoyt that District No. 14 be changed so as to

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* See p. 245.

be composed of Missouri, Arkansas, and Louisiana; and that the States of Nebraska, Oklahoma, and Kansas be placed in District No. 15."

This motion was seconded by Director Hogan, and carried. (District No. 15 is thus comprised of Nebraska, Kansas, Texas, Oklahoma, and Mexico.)

Director Dyer moved that the Zones be accepted as recommended by the Committee.

This motion was seconded by Director Hoyt, and carried by an "aye" and "no" vote.

Director Hogan offered as an amendment:

"That District No. 3 be taken from Zone No. 1 and put in Zone No. 2 which will equalize the resident membership in Zones Nos. 1 and 2."

This motion was then seconded and was lost by show of hands, resulting in 9 "ayes" and 10 "noes."

A motion made by Past-President Talbot, and seconded by Vice-President Wall, was then carried, that nominations for Director for District No. 15 be made in 1924, instead of 1923.

At 12:45 P. M., recess was taken until 2 P. M.

The Board reconvened at 2:15 P. M. with the same attendance as in the forenoon, except that Director O'Connor was present, Past-President Pegram came in at 3:15 P. M., and Messrs. Curtis, Hogan, and Hudson were absent.

Matters Referred to the 1922 Committee on Special Committees

It was reported that the three following matters had been referred by the outgoing Board to the 1922 Committee on Special Committees which, action, after discussion participated in by Messrs. Brown, Chester, Grunsky, Talbot, Wall, Webster, and Yates, was confirmed:

Joint Committee Suggested to Study Housing Problem.

Acceptance by the Society of the Responsibility for Sponsorship and the Organization of a Representative Sectional Committee for the Unification of Existing and Proposed Specifications for Steel Railway Bridges.

Question of Adopting Resolution *re* Pollution of Waters by Industries.

Founder Societies' Joint Finance Committee

On motion, duly seconded, and carried, the Vice-Chairman of the Executive Committee and the Acting Secretary were appointed to represent this Society on the Founder Societies' Joint Finance Committee.

Sidewalk Alterations to Fifty-Seventh Street Property

The Acting Secretary brought up the matter of sidewalk alterations to the Fifty-seventh Street property required by law and, on motion of Director Brown, duly seconded, and carried, the following resolution was adopted:

"*Voted:* That a Committee of three is hereby authorized to be appointed by the President to have full power to contract for the necessary expenditures required by the city on the Fifty-seventh Street property with the understanding that any contract will be signed by the President and Secretary of the Society."

Proposed Congress in Rio de Janeiro, Brazil, in September, 1922

The matter of a proposed Congress in Rio de Janeiro, Brazil, in September, 1922, was reported, this matter having been referred by the outgoing Board to this Board.

On motion of Director Henny, seconded by Director Brown and carried, the Board approved in principle the holding of this Congress.

Professional Records of Members

The Acting Secretary brought up the question of whether members' professional records shall be available to the public. This matter was discussed at the meeting of the Executive Committee on December 6th, 1921, on the protests of two members, and the Committee decided that the records would be public, as stated in letters transmitting the forms to the membership asking for such records which are given voluntarily, but the Executive Committee decided the matter should be discussed by this Board.

Messrs. Brown, Greene, Grunsky, Henny, Ridgway, Webster, and Winsor participated in the discussion, and on motion of Vice-President Grunsky, seconded by Director Henny, the previous action of the Board was adhered to in allowing these records to be available to the public with the definite understanding that the Society assumes no responsibility for the accuracy of the statements.

Development of Agricultural Resources of the United States

The report of the Committee on Pending Legislation Relating to the Development of the Agricultural Resources of the Country,* which was referred by the outgoing Board to this Board, was presented.

On motion of Vice-President Grunsky, seconded by Director Anderson, and carried, this matter was postponed until the next meeting of the Board and copies of this report were ordered to be forwarded each Director.

Proposed Universal Code of Ethics

The report of the Joint Committee on Universal Code of Ethics† was presented, which had been referred by the outgoing Board to this Board.

(Mr. Alvord's remarks‡ to the outgoing Board in this matter were ordered by it presented to this Board as his term as Director has expired. These remarks were read by the Acting Secretary.)

In this connection it was reported that the outgoing Board had recommended to this Board, the favorable consideration of the appointment of a Committee on Professional Conduct.

Discussion in the matter was participated in by Messrs. Anderson, Brown, Henny, Ridgway, Talbot, Wall, and Webster.

On motion of Director Anderson, seconded by Vice-President Ridgway, and carried, the President was empowered to appoint a committee of three to report to the next meeting of the Board on this whole matter of Proposed Universal Code of Ethics and the appointment of a Committee on Professional Conduct.

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* See p. 225.
† See p. 230.
‡ See p. 232.

On motion of Director Anderson, the Board recessed at 3 P. M., to meet as a Membership Committee.

January 20th, 1922.—The Board reconvened at 10:40 A. M.; President John R. Freeman in the chair; Elbert M. Chandler, Acting Secretary; and present, also, Messrs. Anderson, Brown, Chester, Dyer, Grunsky, Henny, Hogan (came in at 10:50 A. M.), Holland (came in at 10:50 A. M.), Hoyt, Huber, Webster, Winsor, and Yates.

STANDING COMMITTEES OF THE BOARD FOR 1922

The matter of the appointment of the Standing Committees of the Board for 1922 was brought up, and on motion of Past-President Webster, seconded by Director Dyer, and carried, the President was empowered to make the nominations for the various committees which he did, as follows:

Executive Committee.—John R. Freeman, *Chairman,* Robert Ridgway, *Vice-Chairman,* A. P. Davis, George H. Pegram, and George S. Webster.

On motion of Past-President Talbot, seconded by Director Henny, and carried, these nominations were confirmed.

Public Relations Committees.—Baxter L. Brown, *Chairman,* Onward Bates, A. H. Markwart, Leonard Metcalf, and G. R. Putman.

On motion of Past-President Talbot, duly seconded, and carried, these nominations were confirmed.

On motion of Past-President Webster, duly seconded, and carried, the President was authorized to fill any vacancies that may occur on this Committee.

Committee on Publications.—John R. Freeman, *Chairman,* C. E. Grunsky, C. W. Hudson, Richard L. Humphrey, and J. J. Yates.

On motion of Director Henny, duly seconded, and carried, these nominations were confirmed.

Committee on Special Committees.—A. P. Davis, *Chairman,* Anson Marston, and George H. Pegram.

On motion of Director Dyer, seconded by Past-President Curtis, and carried, these nominations were confirmed.

On motion of Director Hoyt, seconded by Past-President Talbot, and carried, the President was authorized to appoint the Special Committee provided for in the report of the Committee on the Report of the Committee on Technical Activities* (that is, a Temporary Special Committee on Technical Activities to consist of the Committee on Publications, together with other members).

AMERICAN ENGINEERING STANDARDS COMMITTEE

The matter of filling the vacancy caused by the expiration of the term of H. J. Burt, M. Am. Soc. C. E., as one of the Society's representatives on the American Engineering Standards Committee, was brought up.

Messrs. Talbot and Yates spoke. On motion of Director Brown, duly seconded, and carried, the President was empowered to fill this vacancy.

Recessed at 11:15 A. M., to meet as a Membership Committee.

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* See p. 248.

The Board reconvened at 12.30 P. M.

The report* of the Membership Committee was presented.

On motion, duly seconded and carried, the recommendations of this report which was not read, were adopted as the action of the Board.

Upon motion of Director Henny, duly seconded and unanimously carried, the Acting Secretary was requested to prepare information showing the basis upon which the assessment against the Society was made by the United Engineering Society as compared to the other Founder Societies and be prepared to report at the Dayton meeting.

Fifty-Seventh Street Property

On motion of Past-President Talbot, seconded by Director Henny, and unanimously carried, the Acting Secretary was instructed to prepare a statement to go to the Board of Direction setting forth the details pertaining to the Fifty-seventh Street property with especial reference to the: (1) curb improvement; (2) present lease; (3) status with reference to selling.

Question of Joining Federated American Engineering Societies

On motion of Director Chester, duly seconded, and carried, the Acting Secretary was instructed to give notice to the members of the Board of Direction that the question of this Society becoming a member of the Federated American Engineering Societies would come up at the Dayton meeting of the Board, and the Acting Secretary was further instructed to write to the various Local Sections to ascertain the sentiment on this question and report to their members of the Board of Direction in time for the April meeting.

Calendar Card

On motion of Director Brown, duly seconded, and carried, it was agreed that the publication of the Calendar Card be dispensed with in the future.

Local Sections

On motion of Past-President Talbot, duly seconded, and carried, it was decided that for the purpose of the Local Sections notifying Directors of their attitude on the question of the Federation, the old subdivision of Districts would stand but for the purpose of classifying members, the new districting would be used, and the President was authorized to assign members of the Board to Districts not now represented by a Resident Director.

Adjourned at 12:40 P. M., to meet 10 A. M., on April 3d, 1922, at Dayton, Ohio.

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* *Proceedings*, Am. Soc. C. E., February, 1922, p. 120.

MINUTES OF MEETINGS OF SPECIAL COMMITTEE ON SPECIFICATION FOR BRIDGE DESIGN AND CONSTRUCTION

February 10th, 1922.—The Seventh Meeting of the Committee was called to order at 10:15 A. M., at the University of Pennsylvania, Philadelphia, Pa.

This meeting was planned to consist of a Joint Conference with the Sub-Committee on Bridge Standards of the American Association of State Highway Officials and a regular Committee meeting. At the Joint Conference, there were present of the Committee Messrs. Henry B. Seaman (Chairman), V. H. Cochrane, C. W. Hudson, M. S. Ketchum, J. R. Worcester, F. E. Turneaure, and H. C. Baird (Secretary); and of the Sub-Committee of State Highway Officials, Messrs. J. H. Ames, Bridge Engineer, Iowa Highway Commission; E. E. Brandow, Bridge Engineer, State Highway Department of Pennsylvania; William L. Craven, Bridge Engineer, State Highway Commission of North Carolina; L. N. Edwards, Bridge Engineer, State Highway Commission of Maine; Charles A. Mead, Bridge Engineer, State Highway Commission of New Jersey; S. B. Slack, Bridge Engineer, State Highway Department of Georgia; and E. F. Kelley, Senior Highway Bridge Engineer, U. S. Bureau of Public Roads.

On motion, duly seconded, and carried, Professor Ketchum was unanimously chosen as Chairman of the Joint Meeting. The meeting was opened with a discussion on Highway Loading, with the subject-matter, as prepared by the Committee, before the members. This discussion included the practice in different States for clear roadway allowance, and, on motion, duly seconded, a definition was adopted covering clear roadway width and clear head-room.

The morning session was devoted to a general discussion of impact from trucks and other moving loads, and some interesting data were given by Mr. Ames as the result of numerous experiments made by the Iowa Highway Commission with trucks, tractors, road-rollers, etc. At the conclusion of the discussion, an agreement was reached as to a tentative requirement for impact on floors and trusses.

The afternoon session was opened with a discussion on the general dimensions of trucks and the distribution of loads on axles, on the distribution of concentrated loads on stringers and slabs, and on fill in spandrel concrete arches.

The subject, Recommendations for Live Loads, was exhaustively discussed, during which discussion it was shown that a wide variation of uniform loads exists at the present time among the different State specifications.

On motion, duly seconded, agreement was reached as to the equivalent uniform loads to be adopted for trusses of varying lengths as proposed in the tentative draft prepared by the Committee for this Conference.

Adjourned at 5:30 P. M., to meet at 9 A. M., on February 11th, 1922.

February 11th, 1922.—The meeting was called to order at 9 A. M., at the University of Pennsylvania, Philadelphia, Pa.

This session was devoted principally to the subject of Concrete Bridges. A discussion on the Wearing Surfaces on Roadways was followed by a dis-

cussion on the advisability of using reinforced concrete slab with a surface subject to wear.

A general discussion on Drainage and Water-Proofing brought out a view favoring integral water-proofing as opposed to attempts to make the concrete mixture of water-proof substance.

In considering Materials, reinforcement material was first taken up, the relative merits of plain bars, deformed and twisted bars, square or round bars, and the grade of material being fully discussed. The general opinion favored plain round bars of structural grade and opposed re-rolled material.

The general details of concrete construction, specifications for arches, temperature allowances, and expansion joints completed the discussion under the topic, Concrete Bridges. The matter of truck loads and uniform loads was then taken up for final action and on motion, duly seconded, agreement was reached.

Adjourned at 1:30 P. M.

Regular Meeting of the Special Committee

February 11th, 1922.—The meeting was called to order at 3 P. M., at the University of Pennsylvania, Philadelphia, Pa. Present, Henry B. Seaman (Chairman), V. H. Cochrane, C. W. Hudson, M. S. Ketchum, J. R. Worcester, F. E. Turneaure, and H. C. Baird (Secretary).

On motion, duly seconded, a vote of thanks was extended to the Sub-Committee on Bridge Standards of the American Association of State Highway Officials, for its able and willing co-operation in the work undertaken by the Joint Conference and for the valuable data and information furnished by its members during the discussion.

On motion, duly seconded, various subjects included in Highway Bridge Specifications were assigned to different members of the Committee for the preparation of drafts to be presented for discussion at the next meeting.

On motion, duly seconded, the Committee adjourned at 3:45 P. M., to meet at the call of the Chair.

ITEMS OF INTEREST

The Committee on Publications will be glad to receive communications of general interest to the Society, and will consider them for publication in *Proceedings* in "Items of Interest". This is intended to cover letters or suggestions from our membership concerning matters which are not of a technical character. Such communications, however, must not be controversial or commercial.

UNITED ENGINEERING SOCIETY

Report of the President of United Engineering Society for 1921

To the Trustees of United Engineering Society:

In the affairs of the Founder Societies, events of unusual interest have occurred during 1921. Some of them have affected the activities of United Engineering Society as recorded in the following report.

Important renewals and improvements have been made in Engineering Societies Building. Reductions in prices for some commodities have conduced to slightly lower operating costs. By strict regard to economy in every detail, our income has been made adequate to cover maintenance and operation and to provide for the required addition to the Depreciation and Renewal Fund, but not sufficient to allow payments into this Fund to make up the deficiency of 1920 and other preceding years.

In April, 1921, Mr. Calvert Townley resigned as Trustee representing the American Institute of Electrical Engineers, vacating the office of First Vice-President and the Chairmanship of the Finance Committee. W. L. Saunders, Second Vice-President, was elected First Vice-President and appointed Chairman of the Finance Committee. Mr. Irving E. Moultrop was elected Second Vice-President.

Superintendent Osterberg lost his life as the result of an automobile accident in August, 1921, and Alexander S. Diven, formerly Office Manager for the American Society of Mechanical Engineers, was chosen to fill the vacancy, beginning September 1st, 1921.

The membership of the four Founder Societies at the end of 1921 was 49 938, and of the Associate Societies 24 603, so that a total of 74 541 engineers have headquarters in the Building. Other technical societies holding meetings in the Building have a large aggregate membership in addition.

The Committee on Additional Founder Society, appointed February 26th, 1920, presented reports expressing variant opinions, which, in effect, agreed in

the conclusion that no increase in the number of Founder Societies should be made at present.

A fourth revision of the Charter and By-Laws has been printed.

Two of the Founder Societies, in choosing Trustees for the coming term, appointed men who were completing their second terms for other Founder Societies. Question of the legality of such action under the By-Laws having been raised, an amendment to By-Law 18 was proposed with the advice of Counsel, so that it would read:

"A Trustee shall not be eligible *as a representative of the same Founder Society* for more than two terms consecutively."

New words are in italics. The approval of all four Founder Societies having been obtained, in accordance with By-Law 112, the amendment was adopted at the meeting on January 26th, 1922, by the necessary number of affirmative votes.

There have been no important changes in occupancy of offices in the Building. The American Society of Civil Engineers relinquished Room 1605 in order that it might be allotted to the Illuminating Engineering Society, removing that Society from the eighth floor, thereby giving the National Electric Light Association full possession of the floor allotted to it in 1920. Rooms 101 and 103, on the entrance floor, were allotted to the Federated American Engineering Societies for the Engineering Society Service Bureau.

The Founder Societies gave assent to an arrangement by which each Society should be charged for all space occupied, but not heretofore assessed, and should receive an increased rate of interest on its stated share in the property of United Engineering Society, which arrangement has been put into effect.

Permanent alterations have been made on the fourth floor of the Building by which a committee room was created. This expenditure was financed from the General Reserve Fund, which has been reinbursed from income.

The Building has been carefully maintained and is in excellent condition. The air return pipes of the steam-heating system in the older portion of the Building had so deteriorated as to necessitate renewal. The Webster vacuum return system (in use in the new stories of the Building) was substituted, at less cost and better efficiency. A portion of the hot-water supply piping in the basement had to be renewed. To clear the rust from the remainder of the system and prolong its life, an anti-corrosion equipment was installed, which removed the oxygen from the water, thus greatly reducing its corrosive action.

The Independence Bureau, in accordance with engagement, made its annual inspection of the Building on January 16th, 1921, and reports that it found the Building in excellent condition, except accumulation of combustibles in one store room, and a few minor items (which are being put in acceptable condition). The Bureau suggests more frequent trips by the night watchman, and an emergency warning system within the Building, which matters have the consideration of the House Committee.

On recommendation of the Committee on Entrance Hall and Memorials, a general policy concerning the acceptance and location of memorials in the Building has been adopted. With advice of Counsel, this policy was put into the form of a new By-Law, which was added to the By-Laws at the meeting of January 26th, 1922.

Engineering Societies Library

On application by United Engineering Society to the Carnegie Corporation for financial assistance on behalf of the Library, an appropriation of $10 000 per year for two years was made by the Corporation, for extraordinary library expenses, beginning July 1st, 1921.

The National Electric Light Association informed United Engineering Society that its National Executive Committee had voted an appropriation of $1 000 to the Library in response to its request.

A special appropriation of $1 250 each toward the expenses of the Library for the past year was made by the Civil, Mining, and Mechanical Engineers.

The income and expenses of the Library during 1921 were as follows:

Contributions by four Founder Societies..........	$25 750.02
Library Endowment income......................	4 914.70
Contribution A. I. E. E. Mailloux Fund..........	467.61
Total	$31 132.33
Expenses were	28 001.04
Balance December 31st, 1921.............	$3 131.29
Deficit January 1st, 1921.................	3 191.92
Deficit December 31st, 1921.................	$60.63

Library Service Bureau:

Revenue:		
Surplus January 1st, 1921..................		$710.27
Total billed, Search Department............		8 868.18
Total billed, Photostat Department..........		5 676.36
		$15 254.81
Expenses:		
Salaries, Search Department.......	$8 836.22	
Supplies, Search Department.......	1 397.50	
Salaries, Photostat Department....	3 567.16	
Supplies, Photostat Department....	1 954.53	15 755.41
Operating deficit, December 31st, 1921............		$500.60
Uncollectable accounts written off...............		470.58
		$971.18
Restoration of petty cash..................		25.00
Total deficit, December 31st, 1921................		$946.18

The business transacted by the Library Service Bureau increased from \$2 410.80 in 1915, to \$8 814.93 in 1918, \$22 797.15 in 1920, but declined in 1921 on account of the general depression in business to \$14 544.54. The staff and other expenses have been correspondingly curtailed.

Library Recataloging:

	Appropriations	Receipts
Appropriation, 1921:		
Founder Societies	\$10 000.00	\$9 999.86
Carnegie Corporation	2 500.00	2 500.00
	\$12 500.00	\$12 499.86
Expenses, 1921:		
Deficit, January 1st, 1921	\$1 950.49	
Salaries	13 606.01	15 556.50
Deficit, December 31st, 1921		*\$3 056.64

ENGINEERING FOUNDATION

The annual income of Engineering Foundation is now at the rate of \$25 000. The accumulated unexpended balance on December 31st, 1921, was \$12 958.33. Close relations with National Research Council and contributions to the support of its Division of Engineering were continued. On October 1st, 1921, Alfred D. Flinn, M. Am. Soc. C. E., Secretary of the Foundation, was elected also Chairman of the Division of Engineering.

Important research projects have been assisted, both directly and co-operatively with the Research Council. Among these may be mentioned: The National Advisory Board on Highway Research, Fatigue of Metals, Industrial Education and Training, Graphitic Corrosion of Cast Iron, Personnel Research Federation, and Paint-on-Wood Research.

Work under the agreement of the Foundation with National Research Council and the University of Illinois, on the investigation of the fatigue phenomena of metals, has been completed and a full report printed as *Bulletin 124* of the Engineering Experiment Station of the University of Illinois. A publication on this subject soon to be issued by the Foundation is being prepared.

"Research Narratives" have been published semi-monthly throughout the year. Through its publicity representative, the Foundation has contributed to popular knowledge of research and its value to the United States and its industries.

ENGINEERING COUNCIL

At the beginning of the year, the business of Engineering Council was turned over to the new American Engineering Council. It was voted to pay to Mr. J. Parke Channing the unexpended balance of funds remaining in the treasury of United Engineering Society to the credit of Engineering Council, at the final closing of the Council accounts, in full settlement for

* Against this may be offset \$2 500 received January 3d, 1922, from Carnegie Corporation for the last quarter of 1921.

funds advanced under his guaranty for certain expenses. Two of the Founder Societies, the American Society of Civil Engineers and the American Society of Mechanical Engineers, through United Engineering Society, reimbursed Mr. Channing for their *pro rata* share of the money which he advanced for Engineering Council.

A condensed history of Engineering Council was published in January, 1921, as a 28-page booklet.

John Fritz Medal Board of Award

The John Fritz Medal Board of Award, composed of representatives of the Founder Societies, awarded the medal for 1921 to Sir Robert A. Hadfield "for the invention of manganese steel", and, for 1922, to M. Charles Prosper Eugene Schneider "for achievement in metallurgy of iron and steel, for development of modern ordnance, and for notable patriotic contribution to the winning of the Great War". These medals were taken abroad in June, 1921, by a delegation of twelve engineers, representing the John Fritz Medal Board of Award, the four Founder Societies, the Federated American Engineering Societies, Engineering Foundation, and the Engineers' Club. The presentation of the medal and diploma to Sir Robert A. Hadfield took place on June 29th, 1921, in London, in connection with the Annual Meetings of the Institution of Civil Engineers. The presentation of the medal and diploma to M. Charles Prosper Eugene Schneider took place at a meeting of the Société des Ingénieurs Civils de France, in Paris, on July 8th, 1921.

Engineering Societies Service Bureau

The activities of the Service Bureau were continued under the auspices of the Federated American Engineering Societies. During the year, 1905 applicants for employment were registered at the Bureau and 1365 placed in positions.

Visit of Marshal Foch

Ferdinand Foch, Marshal of France, and after March 25th, 1918, Generalissimo of the Allied Armies in the World War, spent six weeks in America as the guest of the American Legion, sailing away December 14th, 1921. By the courtesy of the Legion, he visited Engineering Societies Building, on December 13th, 1921, to receive a certificate of Honorary Membership in the four Founder Societies, which was presented before a gathering of engineers and friends that overtaxed the capacity of the Auditorium. To commemorate this event, Edward Dean Adams, Fellow, Am. Soc. C. E., and Associate of A. I. E. E., presented to United Engineering Society, a medallion portrait of Marshal Foch, to be suitably placed in the Building.

Alfred Noble Memorial

The American Institute of Consulting Engineers offered to United Engineering Society a bronze tablet commemorating the achievements of the late

Alfred Noble, Past-President, Am. Soc. C. E. This tablet was accepted on recommendation of the Committee on Entrance Hall and Memorials, and will be placed on the wall of the Entrance Hall of the Building.

Presentation of Resolutions to Dr. Durand

Dr. W. F. Durand was present as guest of honor at the November meeting to afford an opportunity for the Founder Societies and the Society of Naval Architects and Marine Engineers to present resolutions expressing appreciation of his services as Chairman of the Committee on Management, of the International Engineering Congress of 1915, in connection with the Panama-Pacific International Exposition at San Francisco, Cal. Dr. Durand accepted the resolutions in behalf of the engineers of the Pacific Coast who had cooperated so heartily in making the Congress possible.

Finances

The income of United Engineering Society for 1921 was	$117 009.93
The expenses were	101 370.21
Balance for the year	$15 639.72

This balance includes $6 724.73 in accounts receivable, and $125 uncollectable accounts written off December 31st, 1921.

Funds held by U. E. S., December 31st, 1921 (Book Values):

Engineering Foundation	$502 066.05
Library Endowment	93 351.25
General Reserve	10 000.00
Depreciation and Renewal	98 639.47
Total	$704,056.77
The real estate owned by U. E. S., cost to January 1st, 1921	$1 957 354.31
Permanent addition to Building during year	1 786.36
Cost to December 31st, 1921 (cannot be reproduced for that sum)	$1 959 140.67
Total net assets	$2 689 834.75

Investments

On February 8th, 1921, the Treasurer visited the Cleveland Trust Company, and formally accepted the securities constituting Mr. Ambrose Swasey's third gift to Engineering Foundation ($200 000), and delivered these securities to the Cleveland Trust Company as custodian, taking a receipt therefor.

For better security a few changes have been made in the investments for the various funds, and cash received has been conservatively invested.

Accounts

The various accounts of the Society have been examined and audited by Messrs. Haskins and Sells, Public Accountants, and their report received, as follows:

Statement of Depreciation and Renewal Fund:

Year.	Additions from operating balance.	Cumulated interest added to the fund.	Expenditures.
1907..............	$5 000.00	......	......
1908..............	5 000.00	......	......
1909..............	5 000.00	......	......
1910..............	5 000.00	......	......
1911..............	5 000.00	......	......
1912..............	5 000.00	......	......
1913..............	10 000.00	......	......
1914..............	10 000.00	$1 441.39	......
1915..............	5 000.00	2 404.28	......
1916..............	10 000.00	2 610.45	......
1917..............	nil	3 581.29	......
1918..............	8 000.00	3 126.37	......
1919..............	10 000.00	4 035.22	......
*1920..............	nil	4 016.16	$818.75
*1921..............	nil	4 837.07	9 594.01
Totals	$83 000 00	$26 052.23	$10 412.76

Summary:

Balance, Jan. 1, 1921.....	$103 396.41
Cumulated interest, 1921..	4 837.07
	$108 233.48
Less expenditures, 1921...	9 594.01
Balance, Jan. 1, 1922....	$98 639.47

Expenditures and Adjustments, 1921:

Heating and hot-water systems (renewals)........	$9 395.91
Adjustment of accrued interest	101.19
Collection, custodial and advisory charges........	96.91
	$9 594.01

At a meeting of the Trustees held November 19th, 1914, it was resolved that beginning with 1915, the Depreciation and Renewal Fund should have the sum of $10 000 added to it each year, in addition to the income from securities held in the Fund. This action was reaffirmed by the Board in 1919. The additions to date have been $37 000 less than required.

Changes in Board Membership

In April, 1921, the resignation of Mr. Calvert Townley, Trustee representing the American Institute of Electrical Engineers, was presented and accepted with regret. Mr. Henry A. Lardner was appointed to be his successor.

The new members joining the Board of Trustees during the year were: Arthur P. Davis, representing Am. Soc. C. E.; Edwin Ludlow, representing Am. Inst. M. E.; Worcester R. Warner, representing Am. Soc. M. E.; and H. H. Barnes, Jr., representing Am. Inst. E. E.

* In 1920, $10 000 was used from uninvested cash of the Depreciation and Renewal Fund to aid in financing permanent improvements to the building, charged to Real Estate and credited to Founders' Equity. For this sum, a note dated January 27th, 1921, was given to this Fund. The operating income balance for 1920 was insufficient to permit any addition to the Depreciation and Renewal Fund. The $10 000 available from operating income balance in 1921 was used to pay the note of January 27th, 1921, that is, for the permanent improvements made in 1920, and so no addition was made to the Depreciation and Renewal Fund in 1921.

The members retiring by rotation at the end of this year are: J. Vipond Davies, representing Am. Soc. C. E.; W. L. Saunders, representing Am. Inst. M. E.; Irving E. Moultrop, representing Am. Soc. M. E.; and Bancroft Gherardi, representing Am. Inst. E. E.

Acknowledgments

Messrs. Parker and Aaron, Counsel, have continued their helpful services. The two important questions on which they rendered advice were: (1) the form of By-Law stating the general policy on accepting and placing memorials in Engineering Building; and (2) Amendment of By-Law 18 to permit a Trustee who had served two terms as the representative of one Founder Society to serve immediately thereafter as Trustee of another Founder Society, of which also he was a member.

Mr. H. G. Morse, as Consulting Architect, made suggestions in relation to the furnishing of the Entrance Hall and the placing of memorials, and rendered services in connection with alterations on the fourth floor and studies of other possibilities for additional store rooms and offices.

It is a pleasure to acknowledge to the various committees appreciation of their loyal and efficient services. The operation of the Building has continued to be directed by the House Committee, consisting of the Secretary of United Engineering Society, Alfred D. Flinn, as Chairman, with the Secretaries of the Founder Societies, Elbert M. Chandler, F. F. Sharpless, Calvin W. Rice, and F. L. Hutchinson, to whom this recognition of their capable and careful performance of duties is tendered.

Mr. Alfred D. Flinn has ably fulfilled the duties of Secretary during the year. Dr. Struthers has completed twelve years as Treasurer, and the thanks of the Trustees are due him for his conscientious and helpful services.

Further details of the activities of Engineering Societies Library and Engineering Foundation are given in their Annual Reports.

The affairs of United Engineering Society are in a satisfactory condition.

Very respectfully,

J. Vipond Davies, *President.*

Extracts from Annual Report of Treasurer for the Year Ending December 31st, 1921

There remained on December 31st, 1921, uninvested cash amounting to $585.21, of which the Cleveland Trust Company held $151.66.

Summary of Funds December 31st, 1921:

Depreciation and Renewal Fund	$98 639.47
Library Endowment Fund	93 351.25
General Reserve Fund	10 000.00
Engineering Foundation Fund	502 066.05
Total	$704 056.77

Repairs and Alterations

During the year, the sum of $15 450.38 was spent for repairs, alterations, and equipment. The total amount, was charged off at the end of the year. A detailed list of these expenditures was presented in the budget for 1921 and approved by the Board of Trustees:

Treasurer's Receipts and Payments, Year 1921

Receipts

Cash on hand, January 1st, 1921		$15 029.02
From Founder and Associate Societies for offices, storage, halls, telephone and miscellaneous	$98 666.45	
From societies not in building for halls and miscellaneous	17 530.79	
For Library, general maintenance and operation	25 291.61	
" Library Service Bureau	16 738.16	
" Library recataloging	12 291.53	
Income collected on Investments and Deposits of U. E. S.	12 116.83	
Income collected on Engineering Foundation investments	24 533.57	
Sale of securities	27 874.38	
From Am. Inst. E. E. for Building Addition	2 500.00	237 543.32
		$252 572.34

Payments

To Engineering Foundation:		
Income from investments less collection charges	$24 258.31	
For securities purchased	25 400.00	
" Building operating expenses	101 370.21	
" Library	27 588.43	
" Library Service Bureau	15 755.41	
" Library recataloging	13 606.01	
" Am. Soc. M. E. note	2 500.00	
" Am. Soc. M. E., Interest on note	206.20	
Collection, custodial and Adv. charges and exchanges	650.83	
For Engineering Council	14 500.00	
" Engineering Society Service Bureau	406.74	
" Permanent improvement charged to capital	1 786.36	
" Renewals in steam system charged to Depreciation and Renewal Fund	9 395.91	
" American Delegation dinner	805.10	
" Miscellaneous	123.48	
Grand total		$238 352.99
Cash on hand, December 31st, 1921		14 219.35
		$252 572.34

Assets and Liabilities

December 31st, 1921

Assets

Property		$1 959 140.67
Land	$540 000.00	
Building	1 361 969.51	
Equipment	33 171.16	
Founders' Preliminary Expenses	24 000.00	
Investments: Foundation		502 066.05
Library		93 351.25
Depreciation and Renewal		98 639.47
General Funds		10 000.00
Cash	$10 477.25	
Special cash funds	50.00	
Due from Cleveland Trust Company	99.16	
Cost of renewals paid from operating cash to be reimbursed from Depreciation and Renewal Fund assets	1 698.47	
Accounts receivable	8 835.98	
Accrued interest receivable on Library Endowment investments	1 246.14	22 407.00
Deferred charges, prepaid insurance		4 230.31
		$2 689 834.75

Liabilities

Founders Equity in Property	$1 959 140.67
Engineering Foundation Reserve	502 066.25
Library Endowment Reserve	93 351.25
Depreciation and Renewal Reserve	98 639 47
General Reserve	10 000.00
Collection on account Osterberg Fund	91.50
Income from Engineering Foundation investments collected and to be paid to Engineering Foundation Board	58.60
Deferred credit, unexpended balance in American Delegation dinner account	52.90
Balance, December 31st, 1921	26 434.31
	$2 689 834.75

Respectfully submitted,

Joseph Struthers, *Treasurer.*

Annual Report of Engineering Foundation

To United Engineering Society:

During 1921 Engineering Foundation was useful in many ways. It had the co-operation of the Founder and other Engineering Societies and of the National Research Council. It is much more widely known than a year ago. Many articles about the Foundation and its work were printed in the publications of the engineering societies and in the technical journals. The name of the Foundation also, has appeared frequently in newspapers and in magazines all over the country.

The "Research Narratives", published semi-monthly since January, 1921, have proved popular and useful. Fifteen hundred copies of each issue are now being mailed to prominent men of means, leading executives and engineers in many industries, engineering societies, technical publications, libraries, colleges, and others. A number of the "Narratives" have been copied by the daily press and have had wide circulation.

Efforts to increase the Endowment Fund were made, but no additions have been secured. Suggestions of several prospective gifts or legacies have been heard. On account of the business depression, the times have not been propitious. From Desmond FitzGerald, Past-President, Am. Soc. C. E., of Boston, Mass., $50 were received for current use.

John L. Harper, M. Am. Soc. C. E., Vice-President and Chief Engineer of the Niagara Falls Power Company, offered to co-operate with Engineering Foundation in the furtherance of research along the line of hydraulics, by making the Company's plant available for experimental work.

The Foundation has continued its substantial contribution to the support of the Division of Engineering of the National Research Council. In this way, aid has been given to a number of worthy projects. A few of these may be mentioned: Welding in its various branches has been advanced through the activities of the American Bureau of Welding and its eleven working committees. Studies of moulding sands, uses of selenium and tellurium, hardness testing of metals, substitute deoxidizers for steel, and core losses in electrical machines, have received active attention from well chosen committees. A committee recently organized with the co-operation of the Division of Biology and Agriculture is undertaking a thorough investigation of marine piling, devoting its attention at first especially to the marine borers which have been causing in recent years damage totaling many millions of dollars.

An appropriation of $1 000 was made toward the administrative expenses of the Advisory Board on Highway Research, of National Research Council. The U. S. Bureau of Public Roads, State highway departments, the U. S. Army, engineering societies, a number of universities, and other organizations are co-operating actively in this research work. The Advisory Board engaged as full-time director, W. K. Hatt, M. Am. Soc. C. E., of Purdue University, a well-known engineer investigator in this field. He began his duties on July 1st, 1921. The First Annual Meeting of the Board, held January 16th, 1922, was a success and showed that much good work had been done.

Work under the agreement of Engineering Foundation with National Research Council and the University of Illinois, on the investigation of the fatigue phenomena of metals, was completed in November, 1921, and a full report printed as *Bulletin 124* of the Engineering Experiment Station of the University of Illinois. The Foundation is preparing a publication on this subject, which will be issued in the near future. Important additions have been made to knowledge of the nature of fatigue, or progressive failure, of metal and of the endurance limits of certain steels under repeated and reversed stresses. The General Electric Company is contributing $30 000 for an extension of the research along lines of special interest to it; this work may extend through another year. Other industrial corporations have expressed

interest, but business conditions have prevented them from taking advantage of this unusual opportunity for experimental work connected with their materials or products.

In close relationship to the investigation of the fatigue of metals, the U. S. Bureau of Mines has been conducting valuable examinations of the connection between non-metallic inclusions in steels and the fatigue endurance of the metal. Owing to curtailment of Governmental appropriation for the first half of 1922, Engineering Foundation was asked to help support this research for that period. After careful consideration, the Foundation reluctantly concluded that this was not an advisable use of its very limited funds.

Industrial education and training is of deep interest to many engineers and all American industries. At the request of the American Society of Mechanical Engineers, the Foundation undertook to organize an investigation of needs and possibilities in this field. A careful preliminary study was made. Extensive bibliographies were prepared and have been in demand. To secure the large financial resources deemed necessary, application was made to the General Education Board, on the strength of a suggestion that the Board was favorably disposed to such a project. The Board found, however, that other commitments of its funds prevented it from undertaking the support of this investigation.

In response to a request from the American Society of Mechanical Engineers, for assistance in a research for determining constants for the upper limits of steam tables, an appropriation of $1 000 was made, to be paid in three annual installments.

Engineering Foundation co-operated with National Research Council in examining the possibilities of bringing about useful co-operation in industrial personnel research. In March, 1921, after two well attended conferences of representatives of many kinds of interests, the Personnel Research Federation was established. Among the members of the Federation are now numbered seven leading universities and colleges, four Bureaus of the Federal Government, the American Federation of Labor, several industrial organizations, and individuals. A well known publisher of conservative scientific periodicals has offered to assume all financial responsibility for producing the *Journal of Personnel Research,* and the Federation has appointed an Editorial Board. The First Annual Meeting, held November 11th, 1921, in Washington, D. C., was well attended and marked by the presentation of many valuable papers.

Other subjects which have received preliminary consideration by Engineering Foundation, and most of which are progressing, include Graphitic Corrosion of Cast Iron, Paint-on-Wood, Rock-drill Steels, Metals by Synthesis, Measurement of Internal Stresses in Steel, Properties of Steel at High Temperatures, and lectures for announcing important discoveries and inventions. Materials have been collected for a Directory of Hydraulic Laboratories, which it is expected to publish soon.

Relations with the Division of Engineering of National Research Council have grown closer and have received careful consideration on several occasions. On October 1st, 1921, on the resignation of Prof. C. A. Adams, as Chairman of the Division, the Secretary of Engineering Foundation was elected to fill the vacancy by co-operative arrangement, while retaining his connection with the Foundation and United Engineering Society.

There has been one change in the membership of the Foundation during the year. Dr. Joseph W. Richards, representing the American Institute of Mining and Metallurgical Engineers, died on October 12th, 1921, and Dr. Arthur L. Walker, of the School of Mines, Columbia University, was elected to fill the vacancy.

Financially, the Foundation's affairs are in sound condition, although a number of worthy projects have had to be declined, because resources were not sufficient. The balance brought forward from 1920 was \$16 091.76. The income during the year was \$27 609.98, the total available, \$43 701.74, and the expenditures, \$30 743.41. A balance of \$12 958.33 was carried forward into 1922. A balance of approximately \$3 000, also, will be left from the \$30 000 fund provided for the Fatigue of Metals Research.

Respectfully submitted,

CHARLES F. RAND, *Chairman.*

Report of Engineering Foundation

Engineering Foundation has on the press a report of its seventh year of activities in research connected with various branches of engineering. The book will contain also an abridged report of the extensive investigation of the fatigue phenomena of metals, made possible by a large contribution from the Foundation. This investigation was conducted at the Engineering Experiment Station of the University of Illinois. In this publication, the Foundation Board gives its supporting Societies information about work done and projects under consideration. Members desiring to obtain a copy of this report when issued should write promptly to the office of Engineering Foundation, Engineering Societies Building, 29 West 39th Street, New York City.

Extract from Report of the Joint Committee on Concrete Culvert Pipe Specifications

This Committee has been in existence for about three years, and was organized for the purpose of standardizing the design of, and requirements for, concrete culvert pipe. The membership of the Committee consists of representatives from seven organizations as follows:

American Society of Civil Engineers............	T. L. D. Hadwen
	George H. Tinker
American Concrete Institute....................	A. B. Cohen
	B. S. Pease
American Association of State Highway Officials.	T. R. Agg
	J. N. Mackall

American Railway Engineering Association......	A. F. Robinson Job Tuthill
American Society for Testing Materials.........	Anson Marston A. E. Phillips
American Concrete Pipe Association............	C. F. Buente Paul Kircher
U. S. Office of Public Roads...................	A. T. Goldbeck T. H. MacDonald

Previous to 1921, H. T. Shelley, M. Am. Soc. C. E., had been one of the representatives of the American Society for Testing Materials and the Chairman of the Committee. In April, 1921, Mr. Shelley resigned, and Anson Marston, M. Am. Soc. C. E., was appointed by the Executive Committee of the American Society for Testing Materials. By a letter-ballot, Dean Marston was made Chairman of the Committee, of which G. E. Warren, Assoc. M. Am. Soc. C. E., is Secretary.

The Committee had been organized previous to 1921, a program of work was laid out and sub-committees were appointed. The various sub-committees had collected and studied data. Several meetings of the Committee and sub-committees had been held, but the work of formulating specifications was held in abeyance until the results of certain experiments on the pressure of earth on culvert pipes were made known and analyzed. These experiments, conducted by the Iowa State College, are now at such a stage that the Committee feels it can utilize the information obtained. An account of these experiments is contained in the Progress Report on Culvert Pipe Investigations, 1915-1921, Project No. 72, of the Engineering Experiment Station, Iowa State College, a copy of which has been placed in the Engineering Societies Library.

ACTIVITIES OF LOCAL SECTIONS*

Annual Meeting of the San Francisco Section

The Annual Meeting of the San Francisco Section was held at the Engineers Club on December 10th, 1921; President Frederick R. Muhs in the chair; Henry D. Dewell, Secretary; and present, also, approximately 100 members and guests.

The following officers for 1922 were elected: President, Thomas H. Means; Vice-Presidents, G. A. M. Elliott and Frank G. White; and Secretary-Treasurer, Henry D. Dewell.

The Secretary presented an informal preliminary annual report, stating that his final report will be published in the 1922 Year Book of the Section.

On motion, duly seconded, the action of the Board of Directors in protesting the summary removal of Capt. Charles H. Lee from his position as Chief of the Division of Water Rights, State Department of Public Works, was approved by the meeting, and the Secretary was instructed to inform Gov. Stephens of this action.

The address of the evening was given by Charles Gilman Hyde, Professor of Sanitary Engineering of the University of California, and Consulting Engineer, the subject being "The New Pumping and Filtration Works for the City of Sacramento, California". Prof. Hyde gave a résumé of the history of the development of the existing municipal water supply system, of the investigations which have been made with respect to an improved supply, and of the chief findings forming the basis on which recommendations for the improvements now under way were justified. He also outlined the experiments and the special technical investigations made in connection with the design of the pumping and filtration works, and described the major design and construction features of the work as proposed and as now built. The estimated cost of the project is $2 700 000. Prof. Hyde illustrated his address with lantern slides and drawings and by exhibits of special materials and apparatus.

Meetings of the Cincinnati Section

A meeting of the Cincinnati Section was called to order at the Hotel Metropole on December 12th, 1921; President Edgar Dow Gilman in the chair; Alphonse M. Westenhoff, Secretary; and present, also, 20 members.

President Gilman introduced the speaker of the evening, Mr. A. E. Morgan, Consulting Engineer of the Miami Conservancy District, who presented an address on "The Engineer Entrepeneur". During his talk, Mr. Morgan explained how the engineer's field of endeavor was continually broadening and how new enterprises were being established by the pioneers in the Profession. The subject was also discussed at length by those present.

The minutes of the meeting of November 17th, 1921, were read and approved.

Mr. F. L. Raschig reported that the memoir of the late Ward Baldwin, M. Am. Soc. C. E., had been completed, and on motion, duly seconded, the memoir was accepted and ordered spread on the minutes.

* For list of Local Sections, Officers, etc., see p. 284.

A discussion followed, the object of which was the bringing of the 1923 Annual Convention of the Society to Cincinnati.

MEETING OF FEBRUARY 13TH, 1922

A meeting was called to order at the Engineers' Club Rooms on February 13th, 1922; President Edgar Dow Gilman, in the chair; and Alphonse M. Westenhoff, Secretary.

Mr. J. A. McDonough reported that the informal luncheon held on January 16th, 1922, was a huge success.

On motion, duly seconded, the Secretary was instructed to notify the local members of the spring meeting of the Society at Dayton, Ohio, and urge all to be present.

On motion, duly seconded, the Secretary was also instructed to notify Mr. H. M. Norris, Chairman of the Speakers and Papers Committee, of the Engineers Club of Cincinnati, that the Section would like to take charge of the meeting to be held in September.

The Secretary was instructed, on motion, duly seconded, to ask local members by letter-ballot to express their views on affiliation with the Federated American Engineering Societies.

On motion, duly seconded, the Secretary was instructed to appoint a committee of three to prepare a slate of nominees for the Section for use in the Society election. President Gilman subsequently appointed Messrs. G. D. Brooke, Chairman, H. D. Loring, and E. N. Floyd, as such committee.

A paper by Mr. E. N. Floyd entitled "Fire Prevention and Protection" was presented and discussed by the members present.

On motion, duly seconded, the Secretary was inst[illegible]ted to thank Mr. Floyd for his excellent paper and also to extend the sympa[illegible]s of the Section on the recent death of his father.

Meeting of Cleveland Secti[illegible]

A meeting of the Cleveland Section was held at [illegible]tel Winton on January 11th, 1922; President A. V. Ruggles in the c[illegible] [illegible]eorge H. Tinker, Secretary; and present, also, 15 members and guests.

The minutes of the meeting of December 14th, 1921, were read and approved, as well as the report of the Secretary-Treasurer.

The Secretary presented communications from the Chamber of Commerce of Cleveland, Congressman Burton, and Mr. T. J. Ray in reference to the report of the River and Harbor Committee. Mr. F. C. Osborn, Chairman of the River and Harbor Committee, reported that a conference had been arranged with the County Commissioners.

The Secretary presented a report of the meeting of the representatives of Sections with representatives of the Cleveland Engineering Society. On motion, duly seconded, the Section approved the recommendation to contribute 50 cents per member to the Cleveland Engineering Society to cover the period to June 1st, 1922.

On motion, duly seconded, the Section approved the recommendation to join in the organization of a Joint Council, consisting of the Presidents and

Secretaries of the various sections of the National Societies and the Cleveland Engineering Society.

A brief address on the "Status of and Future Plans for the Sewage Disposal Works", was made by Mr. G. B. Gascoigne, and the subject was discussed by Messrs. Brown, Thomas, Osborn, Ellms and others.

On motion, duly seconded, the President was instructed to appoint a committee of three to study and report on the advisability of further appropriations for the completion of the Sewage Disposal Works. President Ruggles subsequently appointed Messrs. E. B. Thomas, W. P. Brown, and D. W. Morrow as such committee.

Meeting of Louisiana Section

A regular meeting of the Louisiana Section was held on February 17th, 1922, at the office of the President, 822 Perdido Street, New Orleans, La.; President Ole K. Olsen in the chair; F. A. Muth, Secretary; and present, also, 11 members.

The minutes of the previous meeting were read and approved.

The Secretary presented letters from the Acting Secretary of the Society on which the following action was taken:

Relative to the Society becoming a member of the Federated American Engineering Societies, the Secretary was instructed, on motion, duly seconded, to inform the Acting Secretary that it was the unanimous sense of this meeting as a Section that the Society become a member of the Federated American Engineering Societies. On motion, duly seconded, the Secretary was also instructed to inform the Director from this District of this action.

Relative to the publication of the additional list of books of the Engineering Societies Library, the Secretary was instructed, on motion, duly seconded, to inform the Acting Secretary that as a Section it was felt that the matter should be left in the hands of the Board of Direction to do what it deem best in regard to publishing further lists, etc.

After various other matters had been discussed, the meeting was adjourned and the members present enjoyed the hospitality of President Olsen at an informal smoker.

Annual Meeting of Nashville Section

The Annual Meeting of the Nashville Section was held at the Chamber of Commerce on February 6th, 1922; President Arthur J. Dyer in the chair; Granbery Jackson, Secretary; and present, also, 13 members and guests.

Six new members were added to the Section, and the following officers were elected for the ensuing year: President, B. H. Klyce; Vice-President, Granbery Jackson; and Secretary-Treasurer, L. C. Anderson.

On motion, duly seconded, it was decided that the Section would undertake to have a paper presented at the regular week-day luncheon of the Engineering Association of Nashville for one week in each month during the remainder of the year.

Regular Meeting of New York Section

The regular monthly meeting of the New York Section was held in the Engineering Societies Building on February 15th, 1922; President Nelson P. Lewis in the chair; J. P. J. Williams, Secretary; and present, also, about 128 members and guests.

The minutes of the meeting held January 11th, 1922, were approved.

President Lewis presented a communication from the Acting Secretary of the Parent Society relative to the possibility of joining the Federated American Engineering Societies, which letter requested the Section to express to the Directors representing it on the Board of Direction the sentiment of its members on this question, as the Board would consider the matter at its meeting on April 3d, 1922.

On motion, duly seconded, and carried, the following action was taken:

Whereas, The Board of Direction of the American Society of Civil Engineers at a meeting on January 20th, 1922, instructed the Directors from the various Districts to secure from the Local Sections of those Districts an expression of their opinion in regard to the American Society of Civil Engineers joining the Federated American Engineering Societies; and

Whereas, This question was submitted to letter-ballot of the membership of the Society on November 8th, 1920, and was defeated by 3 278 votes to 2 330 votes; and

Whereas, The receipts of the Society at this time are not sufficient to permit of an adequate return to Local Sections of a portion of dues paid by members of the Parent Society, the amount available this year having been only \$3 500; and

Whereas, A return of \$3.00 per member, as authorized by the present Constitution for the present members of the Society, would entail an expenditure of approximately \$28 000; and

Whereas, The annual expense of joining the Federation, with the present membership, would be in excess of \$10 000 per annum; and

Whereas, It is the belief that the internal welfare of the Society depends upon the increased support of the Local Sections by the Parent Society; and

Whereas, It is evident that the payment of dues to the Federation would be at the expense of the Local Sections,

Resolved: That it is the opinion of the New York Section, Am. Soc. C. E., that it is not expedient to reconsider at this time the decision of the American Society of Civil Engineers not to enter the Federated American Engineering Societies.

The subject for the evening, "How Can the New York Transit Problem Be Solved", was presented by Mr. Daniel L. Turner, Consulting Engineer to the Transit Commission of New York City. He reviewed the growth of transit facilities since their beginning more than 100 years ago, showing that New York was the pioneer city in introducing the horse car, the elevated railway, and the subway with four-track operation and express service. He made it clear that the present problem of relieving congestion, particularly at the evening rush hour, was the same as it was a generation ago, when it differed only in intensity. He emphasized the fundamental principle that all transit facilities should be unified in one whole for the purpose of serving every part of the city equally, and claimed that the principle of private profit

worked directly against this fundamental requirement of public service. He asserted that modern cities should be planned around their transit routes, the latter to be used to develop new and open territory, not to add to congestion by locating in streets already settled.

Mr. Turner claimed that municipal ownership and municipal operation are two separate and distinct things, and advocated municipal ownership with private operation under public control. He urged the extension of municipal ownership to include all the facilities in the city, and advocated a completely unified system, with universal transfers, and monopoly of operation. He concluded by stating that, from a profit-getting standpoint, the interests of the public and the railroads are conflicting, and can never be reconciled, and that the solution lies only in developing city transit along social lines instead of along corporation lines, in order to serve the best interests of the whole community.

Exceptionally interesting discussion of the subject was presented from the floor by Messrs. Edward A. Roberts, Frank J. Sprague, A. G. Brinckerhoff, T. Kennard Thomson, J. P. Fox, and Gen. Andrews. A written discussion from Mr. W. S. Kinnear was received, but, owing to lack of time, was not read.

Annual Meeting of the Northeastern Section

The Annual Meeting of the Northeastern Section was held at the Boston City Club on January 28th, 1922; Chairman F. B. Sanborn in the chair; Charles W. Banks, Secretary; and present, also, 71 members and guests.

Mr. A. H. Morrison presented a paper on "How the Northeastern Section was Started", following which the Secretary-Treasurer presented his report.

Reports of the Annual Meeting of the Society held in New York City on January 18th, 19th, and 20th, 1922, were presented by Messrs. Sanborn, Metcalf, and others.

In the discussion relative to the holding of the 1922 Annual Convention of the Society in Maine, by Mr. A. W. Dean and others, an expression of preference was made in favor of holding the Convention at the Mount Washington Hotel at Bretton Woods, N. H.

After a discussion of the Proposed Affiliation of Technical Societies of Greater Boston by Messrs. F. A. Barbour, W. C. Voss, D. C. Jackson, L. C. Wason, L. Metcalf, and others, it was moved, seconded, and carried, that the Section approve the principle of the proposed affiliation. The Chairman, on motion, duly seconded, was empowered to appoint two members to represent the Section in the conferences relative to the proposed affiliation.

A discussion of the plans of the Section for the coming year, with special reference to its activities in affiliation with the Boston Society, was participated in by Messrs. Barbour, Hamilton, Sanborn, Voss, Metcalf, Wason, Allen, Weston, Varney, and others, the opinion having been expressed in favor of having technical papers prepared and of having these papers presented at meetings held jointly with the Boston Society. On motion, duly seconded, the Executive Committee was empowered to appoint a Committee on Technical Papers.

This meeting was arranged as a Round-Table Luncheon. Of the 71 present, 13 were from outside of Greater Boston and 2 were from outside of Massachusetts. It was also noted that 22 of those present held membership in both the Parent Society and the Boston Society with which the Section is affiliated.

After the adjournment of the meeting, an opportunity was afforded for filing applications for membership, the present active membership being 64, including 60 resident and 4 non-resident members.

Meeting of the Portland Section

A meeting of the Portland Section was held at the University Club on February 17th, 1922; President F. M. Randlett in the chair; C. P. Keyser, Secretary; and present, also, 27 members.

The minutes of the meeting of January 13th, 1922, were read and approved.

A letter from Richard L. Humphrey, M. Am. Soc. C. E., was presented, advising that the report of the Committee on Licensing is not sufficiently formulated to warrant any statements, and, on motion, duly seconded, the letter was ordered filed.

A circular letter to the Local Sections from the Acting Secretary, asking for an opinion on printing additional sections of the catalogue of Engineering Societies Library, was presented and, on motion, duly seconded, the matter was referred to the Directors of the Section for action.

The Secretary presented a letter from the Acting Secretary of the Society requesting the sentiment of members of the Section relative to the Society becoming a member of the Federated American Engineering Societies. President Randlett announced that this question would be debated at the next regular meeting of the Section on March 17th, 1922, and urged the individual members to study the question.

A letter from the Acting Secretary announcing the first spring meeting of the Society at Dayton, Ohio, and the first fall meeting on the Pacific Coast, was received, and, on motion, duly seconded, was ordered filed.

The Secretary presented a letter from the Acting Secretary advising that dues of $1.00 per member would be allocated to Local Sections. Secretary Keyser advised that he had replied to this letter claiming $1.00 for every member of the Society in Oregon. It was moved and seconded that action on the annual dues of the Section, which had been deferred at the Annual Meeting, be taken from the table and the Secretary instructed to bill all members of the Society in Oregon for $2.50 for 1922 dues in the Portland Section.

On motion, duly seconded, an amendment was carried, fixing the amount of dues at $2.00 for members residing in Multnomah County and $1.00 in the jurisdiction outside of Multnomah County.

Prof. Sims, of the Oregon Agricultural College, introduced Mr. Albert Bauer, a member of the Student Chapter of that College, who presented an excellent account of the proposed Hudson River Bridge, including features, estimates, and arguments. The subject was discussed by Director Henny.

Prof. Sims invited the Section to hold its April meeting on the College Campus, which invitation was tentatively accepted by President Randlett.

On motion, duly seconded, President Randlett was instructed to appoint a committee of three to work out first, second, and third prizes to be awarded by the Section to members of the Student Chapter at the Oregon Agricultural College for merit in papers presented. President Randlett subsequently appointed Messrs. Dieck, Clarke, and Bennett as such Committee.

Mr. J. C. Stevens gave a very interesting talk on some large water power projects in the region of Barcelona, Spain, illustrating his remarks with lantern slides. Mr. Stevens was followed by Mr. D. W. Cole, who showed slides illustrating a number of the greater dams of the United States, notably the Shoshone, the Arrowrock, and the Lahontan Dams of the U. S. Reclamation Service.

Annual Meeting of Seattle Section

The Annual Meeting of the Seattle Section was held at the Engineers Club on January 30th, 1922; Joseph Jacobs in the chair; Frank L. Fowler, Secretary; and present, also, 25 members and 7 guests.

The minutes of the last Annual Meeting were read and approved.

The Secretary-Treasurer's report was read and approved.

The speaker of the evening, Mr. James Allen, State Supervisor of Highways, was introduced by Chairman Jacobs. Mr. Allen's address related to highway work in Washington, the work accomplished by the Department, the plans for future work and the more distant plans covering a complete highway system for the State. He also explained the methods of financing and the sources of income for the State Highway Department.

Mr. Allen's address was followed by a general discussion of the highway system, which was participated in by many of the members present.

On motion, duly seconded, a vote of thanks was extended to Mr. Allen for his address.

The following officers were elected for 1922: President, F. F. Sinks; Vice-President, C. C. More; and Secretary-Treasurer, Frank H. Fowler.

After the installation of the new officers, President Sinks opened a discussion as to plans of the Section for 1922, during which many opinions were expressed regarding the future activities of the Section, and it was stated that a definite program for the coming year would be presented in the near future.

Meetings of the Spokane Section

The Annual Meeting of the Spokane Section was held on December 9th, 1921; Vice-President C. A. Burnette in the chair; Charles E. Davis, Secretary; and present, also, 14 members.

The Treasurer's report for 1921 was read and approved.

The following officers were elected for the ensuing year: President, C. A. Burnette; First Vice-President, B. J. Garnett; Second Vice-President, Eugene Logan; and Secretary-Treasurer, Charles E. Davis.

On motion, duly seconded, the dues for the coming year were fixed at $1.00.

On motion, duly seconded, the President and Secretary were appointed as a committee to prepare a budget and present the same to the Parent Society.

Messrs. Butler, Taber, Tiffany, and Davis were, on motion, duly seconded and carried, appointed as the Executive Committee to the Associated Engineers.

On motion, duly seconded, it was decided that if the Executive Committee of the Associated Engineers calls on the Parent Society to propose a name for Chairman of the Associated Engineers for the coming year, the Section will submit the name of Mr. E. G. Taber as first choice, with Mr. R. K. Tiffany as alternate.

Meeting of January 13th, 1922.

A regular meeting of the Spokane Section was held at the East Banquet Annex, Davenport's, on January 13th, 1922; President C. A. Burnette in the chair; Charles E. Davis, Secretary; and present, also, 13 members and guests.

A general discussion of the proposed visit of Gen. Goethals was participated in by those present, and on motion, duly seconded, a committee composed of Messrs. Tiffany, Butler, and Doolittle was appointed to do whatever is possible toward his entertainment.

Meeting of the Providence Section

On the evening of February 21st, 1922, the members of the Providence Section entertained President John R. Freeman of the Society, at a dinner at the University Club, Providence, R. I., at which 14 members were present.

A number of matters of interest pertaining to the Society were considered, particularly the question of joining the Federated American Engineering Societies. On motion, duly seconded, action on this matter was deferred until the March meeting of the Section.

After the dinner, there was a joint meeting with the Municipal Section of the Providence Engineering Society, at which Mr. Freeman gave a very entertaining and instructive talk on India, illustrating his remarks with a number of lantern slides from photographs taken on his recent trip to the Far East.

EMPLOYMENT SERVICE OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

An Engineering Societies Service Bureau was established December 1st, 1918, as an activity of Engineering Council, managed by a board made up of the Secretaries of the four Founder Societies, funds for its maintenance being provided by these Societies. On January 1st, 1921, this Bureau was taken over by The Federated American Engineering Societies and is now known as the Employment Service of that organization. It is co-operating with engineering organizations in all parts of the country and is desirous of increasing such co-operation by working with local engineering associations and clubs. Members of the American Society of Civil Engineers who desire to register should apply for further information, registration forms, etc., to Walter V. Brown, Manager, Engineering Societies Building, 29 West 39th Street, New York City. In order to be included in the list published in *Proceedings,* copy must be received on or before the first Wednesday of each month. All communications should be addressed to Mr. Brown.

EMPLOYMENT BULLETIN

POSITIONS AVAILABLE

BUILDING SUPERINTENDENT or Construction Engineer. Especially on up-to-date apartment houses, office buildings, etc. Must have some drafting experience, as well as experience in estimating; preferably one who has spent most of his time making building estimates for material, tools, construction machinery, and supplies. V–385.

SUPERINTENDENT for cast stone plant. Must be experienced. Location, New York. V–407.

STRUCTURAL STEEL DRAFTSMAN on tunnel work. Men who have worked on, and are familiar with, intricate design such as tunnel shields, theatre balconies, etc., and who know their mathematics. V–427.

STRUCTURAL DRAFTSMAN, steel building. One qualified to design, write specifications, and take off material sheets of quantities, etc., especially for theatre buildings. V–436.

MEN AVAILABLE

GRADUATE ENGINEER, Assoc. M. Am. Soc. C. E., age 36, married. Fifteen years' general experience: Railway maintenance, construction, and location; Panama Canal; design of factory buildings and rubber machinery; design and construction of bridges; management of highway construction; design and construction water-works plant; testing laboratory experience, physical, chemical, electrical. Prefers South, but will go anywhere, including Tropics. Salary, $250 per month, or less, depending on conditions. Good health, eyesight, habits. Present residence, Akron, Ohio. CE–311.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION, M. Am. Soc. C. E., age 47, married. Twenty years in charge of construction and maintenance of railways, reconnaissance, location, design; construction of bridges and buildings, extensive experience on concrete and foundations. Also, seven years on irrigation, drainage, and municipal work. Passed U. S. Civil Service examinations for Irrigation Engineer and for Supervising Engineer. Speaks and writes French fluently. Active, dependable; highest references. Will go anywhere, but prefers United States. Now available. CE–312.

GRADUATE CIVIL ENGINEER, M. Am. Soc. C. E., with long and successful record in executive position in operation of important project in foreign field, seeks new connection with substantial engineering or industrial enterprise. Experience covers office, factory, and ship administration, scientific investigation, surveys of all classes, statistics, reports, and publications. Intimate contact with foreign business development, port works, and public works. Moderate initial salary for organization offering advancement. CE–313.

GRADUATE CIVIL ENGINEER AND CONSTRUCTION SUPERINTENDENT, Jun. Am. Soc. C. E., age 29, single. Officer in A. E. F., France, honorable discharge as Captain of Engineers. Experienced field and office man on heavy excavations, concrete abutments, and retaining walls, railroad, road, and bridge work. Has worked on large drainage canal. At present, Assistant Resident Engineer of a large oil refinery, in charge of all construction and maintenance; $6 000 000

work done in last two years. Desires similar work, or hydro-electric work. Available March 15th. Chicago, Ill. CE–314.

MILL ARCHITECT AND ENGINEER, Assoc. M. Am. Soc. C. E., age 38, married. Fourteen years' experience designing pulp and paper mills, with appurtenant hydraulic and steam-power developments. Capable of taking responsible charge of purchase and arrangement of equipment, architecture, structural design, power requirements, specifications, and contracts. CE–315.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E., age 35, married. Desires position teaching mathematical and engineering subjects or other engineering work. Ten years' practical experience on highways, hydrographic surveying, cement testing, and structural engineering. Teaching since 1919. Present salary, $2 500. Available in June. CE–316.

ENGINEER EXECUTIVE desires connection with responsible concern as Sales Engineer for Baltimore, Md., and vicinity, or as Superintendent for contractor or large manufacturing plant. CE–317.

CONSTRUCTION AND HYDRAULIC ENGINEER, M. Am. Soc. C. E., with sixteen years' experience, competent to take full charge of investigating, constructing, and operating hydro-electric power plants, both high and low head, is open for immediate engagement with water power company or contractor doing water power work. Most of experience in plants of considerable magnitude. CE–318.

EXECUTIVE ENGINEER, M. Am. Soc. C. E., technical graduate, age 35. Thirteen years' experience in office and field on subways, viaducts, steel and reinforced concrete industrial buildings, roads, railroads, power plants, water and sewerage systems, and installation of mechanical and electrical equipment. Able executive and organizer. Excellent references. CE–319.

ENGINEER, Assoc. M. Am. Soc. C. E., age 29. Ten years' broad experience along both civil and mechanical lines; municipal and county works; contract construction. Lieut., A. E. F., during World War. For more than two years to date in charge as Engineer and Assistant Superintendent of large public utility. Desires permanent position where advancement is possible. Minimum salary $3 000. CE–320.

GRADUATE CIVIL ENGINEER, degree 1913, Assoc. M. Am. Soc. C. E., age 32, married. Nine years' experience in concrete construction, industrial buildings, irrigation, roads and municipal engineering. Experience includes design, inspection, and estimating. Would prefer position with general contractor or consulting engineer. CE–321.

CONSTRUCTION SUPERINTENDENT, Experienced on highway and railroad work, bridges, piers, pile-driving, dredging, coffer-dams, caissons, etc. Good organizer and executive and capable of taking entire responsibility on large construction operations. Available now at moderate salary. CE–322.

ENGINEER AND SUPERINTENDENT OF CONSTRUCTION, Assoc. M. Am. Soc. C. E., technical graduate, age 43, desires position with engineering firm or contractor. Twenty years' varied experience in office and field as Engineer, Superintendent of Construction, and Executive, city improvements, water-works, streets and pavements, river and canal improvements, dredging, tunnels, deep foundations, steel and concrete structures, machinery, etc. Excellent record and reference. Available April 1st. CE–323.

ANNOUNCEMENTS

The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

PROGRAM FOR MONTHLY SOCIETY MEETINGS

The Publication Committee announces the following tentative program covering the monthly meetings up to the summer recess. In each case, the meetings will be held on the Fifth Floor of the Engineering Societies Building, 33 West 39th St., New York City, at 8 P. M., on the days noted.

April 5th, 1922.—A regular monthly business meeting will be held, at which a paper by Gustav Lindenthal, M. Am. Soc. C. E., entitled, "The Continuous Truss Bridge Over the Ohio River at Sciotoville, Ohio, for the Chesapeake and Ohio Northern Railway", will be presented for discussion. This paper appears in this number of *Proceedings.*

May 3d, 1922.—Paper by Arthur T. Safford, M. Am. Soc. C. E., and Edward Pierce Hamilton, Esq., entitled "The American Mixed-Flow Turbine and Its Setting", to be published in April *Proceedings,* and presented by Mr. Safford for discussion.

June 7th, 1922.—Informal discussion on "Tentative Specifications for Steel Railway Bridges", submitted as a Progress Report of the Special Committee on Specifications for Bridge Design and Construction, and published in the December, 1921, *Proceedings.*

SPRING SOCIETY MEETING

April 5th, 1922, 10 A. M.—Symposium on Flood Problems: "Flood Conditions in Canada", by J. G. Sullivan, M. Am. Soc. C. E., President, Engineering Institute of Canada; "The Relation of the Federal Government to National Flood Problems", by Major-General Lansing H. Beach, M. Am. Soc. C. E., Chief of Engineers, United States Army.

April 5th, 2 P. M.—"Flood Problems in China", by John R. Freeman, President, Am. Soc. C. E.; "Methods of Flood Prevention in the Mississippi Valley", by J. A. Ockerson, Past-President, Am. Soc. C. E., Member, Mississippi River Commission; "Relation of Flood Problems to Power and Irrigation Development in the Rocky Mountain States", by A. P. Davis, Past-President, Am. Soc. C. E., Director, United States Reclamation Service; "Flood Prevention Methods on the Pacific Slope", by C. E. Grunsky, Vice-President, Am. Soc. C. E.; and "Standing Waves in Rivers", by N. C. Grover, M. Am. Soc. C. E., Chief Hydraulic Engineer, U. S. Geological Survey, Washington, D. C. These papers will be followed by ten-minute discussions led by J. B. Challies, M. Am. Soc. C. E., Director, Dominion Water Power Branch, Department of the Interior, Ottawa, Ont., Canada; Morris Knowles, M. Am. Soc. C. E., Consulting Engineer, Pittsburgh, Pa.; Harrison P.

Eddy, M. Am. Soc. C. E., Consulting Engineer, Boston, Mass., George M. Lehman, M. Am. Soc. C. E., Engineer, Department of Internal Affairs for Pennsylvania, Harrisburg, Pa.

April 5th, 8:15 P. M.—"Flood Problems of the Miami Valley and Their Solution", papers by Arthur E. Morgan, M. Am. Soc. C. E., Former Chief Engineer, Miami Conservancy District, and Charles H. Paul, M. Am. Soc. C. E., Chief Engineer, Miami Conservancy District, Dayton, Ohio.

April 6th, 1922, 9:30 A. M.—Excursion to Englewood Dam.

April 6th, 12 M.—Luncheon at plant of the National Cash Register Company.

April 6th, 3 P. M.—Excursion to Huffman Dam.

April 6th, 6:30 P. M.—Dinner and Smoker at the Miami Hotel. Speaker: Colonel E. A. Deeds, "Human Phases of the Miami Conservancy Project".

April 7th, 1922, 9:30 A. M.—Inspection of Dayton Channel Improvement work.

April 7th, 10 A. M.—Inspection of McCook Aviation Field.

April 7th, 12:40 P. M.—Luncheon and excursion to American Rolling Mill Plant, at Middletown, Ohio.

All members expecting to attend this meeting should make hotel reservations in advance. The rates at the Miami Hotel are $2.50 to $3.50, all rooms with bath; at the Gibbons Hotel, the rates are $2.00 per day and up, without bath.

All excursions and social functions are in the hands of the Dayton Local Section, the officers of which are:

President	Charles H. Paul
First Vice-President	J. H. Kimball
Second Vice-President	O. N. Floyd
Secretary-Treasurer	K. C. Grant

and the Committee of Local Arrangements for the Spring Meeting composed of:

H. S. R. McCurdy, *Chairman,*
J. K. Grannis,
E. L. Chandler,
G. V. Clow,
F. J. Cellarius,
Charles H. Paul, } *ex-officio.*
K. C. Grant, }

The technical program has been prepared under the direction of the Committee on Publications.

SEARCHES IN THE LIBRARY

As the Library of the American Society of Civil Engineers has been merged in the Engineering Societies Library, requests for searches, copies, translations, etc., should be addressed to the Director, Engineering Societies Library, 29

West 39th Street, New York City, who will gladly give information concerning the charges for the various kinds of service. A more comprehensive statement in regard to this matter will be found on page 21 of the Year Book for 1921.

LOCAL SECTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Section (Constitution Approved by Board, 1905).

Thomas H. Means, President; H. D. Dewell, Secretary-Treasurer, 503 Market Street, San Francisco, Cal.

Bi-monthly meetings are held at 6 P. M., at the Engineers' Club, 57 Post Street, on the third Tuesday of February, April, June, August, October, and December, the last being the Annual Meeting. Informal luncheons are held at noon, every Wednesday, at the Engineers' Club. All members of the Society will be gladly welcomed.

Colorado Section (Constitution Approved by Board, 1909).

A. N. Miller, President; Thomas H. Olds, Acting Secretary-Treasurer, First National Bank Building, Denver, Colo.

Meetings are held on the second Monday of each month, except July and August, usually preceded by an informal dinner. Weekly luncheons are held on Wednesday, at 12.30 P. M., at Daniels and Fisher's. Visiting members of the Society are urged to attend.

Atlanta Section (Constitution Approved by Board, 1912).

William C. Spiker, President; Frederick H. McDonald, Secretary-Treasurer, 1530 Healey Building, Atlanta, Ga.

Informal luncheons are held on the second Tuesday of each month, at 1.00 P. M., at the Ansley Hotel, to which visiting members of the Society are welcome. Visitors desiring information will telephone the Secretary.

Baltimore Section (Constitution Approved by Board, 1914).

Ezra B. Whitman, President; George S. Robertson, Sr., Secretary-Treasurer, 1628 Linden Avenue, Baltimore, Md.

Buffalo Section (Constitution Approved by Board, 1921).

A. L. Johnson, President; Bruce L. Cushing, Secretary-Treasurer, 80 West Genessee Street, Buffalo, N. Y.

Central Ohio Section (Constitution Approved by Board, 1921).

F. H. Eno, President; H. F. Schryver, Secretary, 405 New York Central Building, Columbus, Ohio.

Meetings are held at the rooms of the Engineers' Club of Columbus in the Southern Hotel. The Annual Meeting is held on the second Friday of November and at least two other meetings are held each year, the dates of which are designated by the Board of Direction of the Section.

Cincinnati Section (Constitution Approved by Board, 1920).

Edgar Dow Gilman, President; Alphonse M. Westenhoff, Secretary, 709 Gwynne Bldg., Cincinnati, Ohio.

Cleveland Section (Constitution Approved by Board, 1915).

A. V. Ruggles, President; George H. Tinker, Secretary-Treasurer, 516 Columbia Building, Cleveland, Ohio.

Regular meetings are held on the second Wednesday of each month, at 12.15 P. M., in the rooms of the Section, Hotel Winton. Luncheon is served, and all visiting members of the Society are invited to attend.

Connecticut Section (Constitution Approved by Board, 1919).

William J. Backes, President; Clarence M. Blair, Secretary-Treasurer, 785 Edgewood Avenue, New Haven, Conn.

The Annual Meeting is held in April; fortnightly meetings alternate between Hartford and New Haven, Conn. These meetings are informal luncheon gatherings, held usually at noon on Saturday. Members are privileged to invite guests regardless of their affiliation as engineers.

Dayton Section (Constitution Approved by Board, 1922).

Charles H. Paul, President; K. C. Grant, Secretary-Treasurer, Winters Bank Building, Dayton, Ohio.

Detroit Section (Constitution Approved by Board, 1916).

H. H. Esselstyn, President; Alex. Linn Trout, Secretary-Treasurer, 1716 Walnut Street, Ann Arbor, Mich.

Regular meetings are held on the second Friday of December, April, and October, the last being the Annual Meeting.

District of Columbia Section (Constitution Approved by Board, 1916).

Gratz B. Strickler, President; James H. Van Wagenen, Secretary-Treasurer, 2001 Sixteenth Street, N. W., Washington, D. C.

Duluth Section (Constitution Approved by Board, 1917).

John L. Pickles, President; Walter G. Zimmermann, Secretary, 203 Wolvin Building, Duluth, Minn.

Regular meetings are held at noon on the third Monday of each month, usually at the Kitchi Gammi Club, to which visiting members of the Society will be welcomed. The Annual Meeting is held on the third Monday in May.

Illinois Section (Constitution Approved by Board, 1916).

A. J. Hammond, President; W. D. Gerber, Secretary-Treasurer, 133 West Washington Street, Chicago, Ill.

Regular meetings are held on the second Monday of March, June, September, and December, the last being the Annual Meeting.

Iowa Section (Constitution Approved by Board, 1920).

J. H. Dunlap, President; R. W. Crum, Secretary, Care, Iowa State Highway Commission, Ames, Iowa.

Kansas City (Mo.) Section (Constitution Approved by Board, 1921).

John V. Hanna, President; Henry C. Tammen, Secretary-Treasurer, 1012 Baltimore Avenue, Kansas City, Mo.

Regular meetings of the Section are held on the first Tuesday of March, June, September, and December, the last being the Annual Meeting. The members of the Kansas City Engineers' Club meet at luncheon at the University Club every Tuesday from 12 M. to 2 P. M., and all members of the Society are invited to attend these luncheons.

Kansas Section (Constitution Approved by Board, 1920).

L. E. Conrad, President; Frank S. Altman, Secretary-Treasurer, 1114 Garfield Avenue, Topeka, Kans.

Los Angeles Section (Constitution Approved by Board, 1913).

Ralph J. Reed, President; Floyd G. Dessery, Secretary, 619 Central Building, Los Angeles, Cal.

Regular monthly meetings are held on the second Wednesday of each month, the Annual Meeting in December. Informal luncheons in connection with the Joint Technical Societies of Los Angeles are held at 12.15 P. M., every Thursday at the Broadway Department Store Café.

Louisiana Section (Constitution Approved by Board, 1914).

Ole K. Olsen, President; F. A. Muth, Secretary, 224 Custom House Building, New Orleans, La.

Regular meetings are held at The Cabildo, New Orleans, La., on the first Monday of January, April, July, and October.

Nashville Section (Constitution Approved by Board, 1921).

B. H. Klyce, President; L. C. Anderson, Secretary-Treasurer, Bridge Building, Nashville, Tenn.

Nebraska Section (Constitution Approved by Board, 1917).

William Grant, President; Homer V. Knouse, Secretary-Treasurer, 200 City Hall, Omaha, Nebr.

Regular meetings are held on the first Saturday of each month, except July and August. The Annual Meeting is held in Lincoln, Nebr., on the second Friday in January. Visiting members of the Society are especially urged to communicate with the Secretary when in the city.

New York Section (Constitution Approved by Board, 1920).

Nelson P. Lewis, President; J. P. J. Williams, Secretary, 33 West 39th Street, New York City.

Regular meetings are held in the Engineering Societies Building, 29 West 39th Street, New York City, on the third Wednesday of each month, except January and the Annual Meeting in May, held on the second Wednesday of the month.

Northeastern Section (Constitution Approved by Board, 1921).

Frank B. Sanborn, Chairman; Charles W. Banks, Secretary, Wentworth Institute, Boston, Mass.

Northwestern Section (Constitution Approved by Board, 1914).

Charles L. Pillsbury, President; Paul C. Gauger, Secretary, 945 Osceola Avenue, St. Paul, Minn.

Meetings are held bi-monthly, alternating between St. Paul and Minneapolis, on the third Friday of each month.

Oklahoma Section (Constitution Approved by Board, 1920).

Max L. Cunningham, President; R. E. Brownell, Secretary-Treasurer, 402 First National Bank Building, Oklahoma, Okla.

Philadelphia Section (Constitution Approved by Board, 1913).

Benjamin Franklin, President; S. C. Hollister, Secretary, 1200 Land Title Building, Philadelphia, Pa.

Regular meetings are held at the Engineers' Club on the first Monday in January, April, and October, the last being the Annual Meeting. Special meetings are also held at times announced in advance.

Pittsburgh Section (Constitution Approved by Board, 1918).

J. N. Chester, President; Nathan Schein, Secretary-Treasurer, 1510 Carson Street, Pittsburgh, Pa.

Portland (Ore.) Section (Constitution Approved by Board, 1913).

F. M. Randlett, President; C. P. Keyser, Secretary, 318 City Hall, Portland, Ore.

Meetings are held regularly on the third Friday of each month. All members of the Society in any grade are cordially invited to attend.

Providence (R. I.) Section (Constitution Approved by Board, 1920).

Sydney Wilmot, Chairman; Robert L. Bowen, Secretary-Treasurer, 26 Sycamore Street, Providence, R. I.

The Section regularly holds meetings jointly with the Structural and Municipal Sections of the Providence Engineering Society, at the Society Rooms, 29 Waterman Street, on the fourth Tuesday of each month, from September to May. The Annual Meeting is held in May. All visiting members of the Society are cordially invited to attend these meetings.

St. Louis Section (Constitution Approved by Board, 1914).

E. B. Fay, President; William C. E. Becker, Secretary-Treasurer, 426 City Hall, St. Louis, Mo.

The Annual Meeting is held on the fourth Monday in November. Two meetings each year for the presentation and discussion of technical papers are held in the Auditorium of the Engineers' Club, and are open to members of the Associated Societies. Other "get-together" meetings are held regularly for dinner or luncheon on the fourth Monday of each month, except July, August, and November.

San Diego Section (Constitution Approved by Board, 1915).

F. J. Grumm, President; J. Y. Jewett, Secretary-Treasurer, Administration Building, Balboa Park, San Diego, Cal.

Regular meetings are held on the third Tuesday of each month at the Chamber of Commerce. Visiting members of the Society are invited to attend.

Seattle Section (Constitution Approved by Board, 1913).

F. F. Sinks, President; Frank H. Fowler, Secretary-Treasurer, 1319 L. C. Smith Building, Seattle, Wash.

Regular meetings, with luncheon, are held at the Engineers' Club, on the last Monday of each month. All members in any grade of the Society are cordially invited to attend, and if located in this District for any length of time, their membership in the Section will be appreciated.

Spokane Section (Constitution Approved by Board, 1914).

C. A. Burnette, President; Charles E. Davis, Secretary-Treasurer, 401 City Hall, Spokane, Wash.

Meetings are held on the second Friday of each month. These meetings are noonday luncheons at Davenport's, and all visiting members of the Society are invited to attend.

Texas Section (Constitution Approved by Board, 1913).

E. B. Cushing, President; E. N. Noyes, Secretary, 1107 Dallas County Bank Building, Dallas, Tex.

Utah Section (Constitution Approved by Board, 1916).

W. R. Armstrong, President; H. S. Kleinschmidt, Secretary-Treasurer, 222 Felt Building, Salt Lake City, Utah.

The Annual Meeting is held on the first Wednesday in April. The time of other meetings is not fixed, but this information will be furnished on application to the Secretary.

STUDENT CHAPTERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS*

Stanford University Student Chapter, Organized 1920.

R. I. Hill, President; John H. Colton, Corresponding Secretary, Box 121, Stanford, Cal.

* By a recent ruling of the Board of Direction, the minimum membership of a Student Chapter has been fixed at 12 instead of 20.

Alabama Polytechnic Institute Student Chapter, Organized 1921.

Alfred D. Boyd, Secretary, Alabama Polytechnic Institute, Auburn, Ala.

Braune Civil Engineering Society (University of Cincinnati) Student Chapter, Organized 1920.

John W. Guilday, President; C. A. Harrell, Secretary of Section 10; R. Blickensderfer, Secretary of Section 20; University of Cincinnati, Cincinnati, Ohio.

Bucknell University Student Chapter, Organized 1921.

Ralph F. Hartz, President; Donald A. Davis, Secretary, Bucknell University, Lewisburg, Pa.

California Institute of Technology Student Chapter, Organized 1921.

W. M. Taggart, President; Douglas A. Stromsoe, Secretary, California Institute of Technology, Pasadena, Cal.

Carnegie Institute of Technology Student Chapter, Organized 1922.

H. T. Ward, President; J. K. Elliott, Secretary, Carnegie Institute of Technology, Pittsburgh, Pa.

Cornell University Student Chapter, Organized 1921.

T. D. Finn, Jr., President; James Hannigan, Secretary-Treasurer, Lincoln Hall, Cornell University, Ithaca, N. Y.

Drexel Institute Student Chapter, Organized 1920.

C. V. Nishwitz, Chairman; Raymond Radbill, Secretary, Drexel Institute, Philadelphia, Pa.

Iowa State College Student Chapter, Organized 1920.

Raymond L. Whannel, President; C. La Verne Day, Secretary, Iowa State College, Ames, Iowa.

Johns Hopkins University Student Chapter, Organized 1921.

W. A. Randall, President; I. M. Zeskind, Secretary, Johns Hopkins University, Baltimore, Md.

Lafayette College Student Chapter, Organized 1922.

Douglas M. Brown, President; Ivan C. Blickenstaff, Secretary, Lafayette College, Easton, Pa.

Massachusetts Institute of Technology Student Chapter, Organized 1921.

D. H. McCreery, President; T. S. Wray, Secretary, Massachusetts Institute of Technology, Cambridge, Mass.

Montana State College Student Chapter, Organized 1922.

Merrill J. Alquist, President; Emmett Moore, Secretary, 921 South Third Avenue, Bozeman, Mont.

New York University Student Chapter, Organized 1921.

George H. Martin, President; Abram J. Jacobs, Secretary, 302 Gould Hall. New York University, New York City.

Ohio State University Student Chapter, Organized 1922.

O. W. Merrell, President; William M. Ruddicks, Secretary, 65 Thirteenth Avenue, Columbus, Ohio.

Oregon State Agricultural College Student Chapter, Organized 1921.

Richard D. Slater, President; Wilbur H. Welch, Secretary, Oregon State Agricultural College, Corvallis, Ore.

Pennsylvania State College Student Chapter, Organized 1920.

Arthur H. McFadden, President; William W. Seltzer, Secretary, Pennsylvania State College, State College, Pa.

Polytechnic Institute of Brooklyn Student Chapter, Organized 1921.

W. C. Hanning, President; S. Lordi, Secretary, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Purdue University Student Chapter, Organized 1921.

R. O. Edwards, President; W. C. Mason, Secretary-Treasurer, Purdue University, West Lafayette, Ind.

Rensselaer Polytechnic Institute Student Chapter, Organized 1920.

William Minot Thomas, President; Earl D. Hopkins, Secretary, 147 Eighth Street, Troy, N. Y.

Rose Polytechnic Institute Student Chapter, Organized 1921.

Robert Cash, President; F. Ray Martin, Secretary-Treasurer, Rose Polytechnic Institute, Terre Haute, Ind.

Rutgers College Student Chapter, Organized 1921.

L. C. Kuhl, President; A. C. Ely, Secretary, 105 Winants Hall, Rutgers College, New Brunswick, N. J.

State University of Iowa Student Chapter, Organized 1921.

James Fred Phillips, President; Louis E. Baggs, Secretary, State University of Iowa, Iowa City, Iowa.

Swarthmore College Student Chapter, Organized 1921.

Frank Lemke, President; H. Chandlee Turner, Jr., Secretary, Swarthmore College, Swarthmore, Pa.

Syracuse University Student Chapter, Organized 1921.

Arthur V. Dollard, Secretary, College of Applied Science, Syracuse University, Syracuse, N. Y.

University of California Student Chapter, Organized 1921.

H. G. Gerdes, Secretary, Care, Prof. Charles Derleth, Jr., College of Civil Engineering, University of California, Berkeley, Cal.

University of Colorado Student Chapter, Organized 1920.

Herbert Altvater, President; Charles Bowden, Secretary, 1229 University Avenue, Boulder, Colo.

University of Illinois Student Chapter, Organized 1921.

A. L. R. Sanders, President; M. E. Jansson, Secretary, University of Illinois, Urbana, Ill.

University of Kansas Student Chapter, Organized 1921.

W. W. Hoagland, President; Waldo G. Bowman, Secretary, 1106 Ohio Street, Lawrence, Kans.

University of Kentucky Student Chapter, Organized 1921.

H. J. Beam, President; H. E. Glenn, Secretary-Treasurer, 348 Harrison Avenue, Lexington, Ky.

University of Maine Student Chapter, Organized 1921.

George H. Ferguson, Jr., Secretary, University of Maine, Orono, Me.

University of Minnesota Student Chapter, Organized 1921.

C. L. Swanson, President, 1716 Tyler Street, N. E., Minneapolis, Minn.

University of Missouri Student Chapter, Organized 1922.

J. D. Sandker, Secretary, 407 West Broadway, Columbia, Mo.

University of Nebraska Student Chapter, Organized 1921.

J. E. Applegate, President; W. H. Mengel, Secretary, University of Nebraska, Lincoln, Nebr.

University of North Carolina Student Chapter, Organized 1921.

H. G. Baity, President; L. I. Lassiter, Secretary, University of North Carolina, Chapel Hill, N. C.

University of Pennsylvania Student Chapter, Organized 1920.

Charles W. Foppert, President; Fred Welchy, Secretary, University of Pennsylvania, Philadelphia, Pa.

University of Pittsburgh Student Chapter, Organized 1921.

L. W. Fletcher, President; J. M. Daniels, Secretary, University of Pittsburgh, Pittsburgh, Pa.

University of Texas Student Chapter, Organized 1921.

Frank Cannon, President; Claude Riney, Secretary, 1908 Wichita Street, Austin, Tex.

University of Washington Student Chapter, Organized 1921.

B. W. Brown, President; G. E. Large, Secretary, 4518 Eleventh Avenue, N. E., Seattle, Wash.

University of Wisconsin Student Chapter, Organized 1921.

E. K. Loverud, President; L. H. Kessler, Secretary, 235 West Gilman Street, Madison, Wis.

Virginia Military Institute Student Chapter, Organized 1921.

Benjamin F. Parrott, President; R. G. Hunt, Secretary-Treasurer, Virginia Military Institute, Lexington, Va.

Virginia Polytechnic Institute Student Chapter, Organized 1922.

W. S. Miles, President; J. Byron Herring, Secretary, Virginia Polytechnic Institute, Blacksburg, Va.

Washington University Collimation Club Student Chapter, Organized 1920.

William D. Rolfe, President; Erwin Bloss, Secretary, Washington University, St. Louis, Mo.

West Virginia University Student Chapter, Organized 1921.

J. E. Wheeler. President; Milton Jarrell, Secretary, 113 Beverely Avenue, Morgantown, W. Va.

Yale University Student Chapter, Organized 1921.

W. S. Moore, President; T. T. McCrosky, Secretary, Sheffield Scientific School, Yale University, New Haven, Conn.

NEW BOOKS*

(From February 1st to February 28th, 1922)

The statements made in these notices are taken from the books themselves, and this Society is not responsible for them.

DONATIONS TO ENGINEERING SOCIETIES LIBRARY

PRINCIPLES OF ALTERATING CURRENTS.

By Ralph R. Lawrence. (Electrical Engineering Texts.) N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 432 pp., 8 x 6 in., cloth. $4.00.

The author presents herein a textbook developed from notes on alternating currents, used for several years at the Massachusetts Institute of Technology with the junior students in electrical engineering.

RAYS OF POSITIVE ELECTRICITY

And Their Application to Chemical Analyses. By Sir J. J. Thomson. Second Edition. (Monographs on Physics.) Lond. and N. Y., Longmans, Green and Co., 1921. 234 pp., illus., pl., 9 x 6 in., cloth. $5.25.

This work gives an account of the experiments on positive rays which have been made at the Cavendish Laboratory, together with accounts of researches on the Doppler effect in positive rays and on anode rays. Special attention is given in this new edition to those properties of positive rays which seem to throw light on the structure of molecules and atoms and on chemical combination. This edition contains a considerable amount of new matter, both text and plates.

MANAGEMENT OF ACCUMULATORS.

By Sir David Salomons. Ninth Edition. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd. 178 pp., illus., 7 x 5 in., cloth. $3.00.

Earlier editions of this work have appeared as the first volume of "Electric Light Installations and the Management of Accumulators". This edition, which is largely rewritten, gives a general survey of the construction, management, and use of storage batteries, adapted to use by owners and users. Particular attention is given to the technique of charging and discharging, and to failures.

AIRPLANE ENGINE ENCYCLOPEDIA.

By Glenn D. Angle. Dayton, Ohio, Otterbein Press, 1921. 547 pp., illus., diagrams, 9 x 6 in., cloth. $7.50.

A reference book for those interested in airplane engines. Contains information concerning the design, sizes, construction, and performance of the engines of about 175 makers, arranged by names. The subject-matter is based on information from original sources and the leading books and periodicals, and includes every engine known to the author.

AUTOMOTIVE REPAIR.

By J. C. Wright. Vol. 1. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1921. 530 pp., illus., diagrams, 9 x 6 in., cloth. $3.50.

This book is for the repairman or owner who is expected to make general repairs and keep a car fit for operation. One hundred and eighteen jobs are given, with complete instructions. These are divided into chassis, engine, electrical, body, and radiator work, and "trouble shooting", and cover, it is said, 95% of all the problems which will confront the repairer. The second section of the book presents the theoretical and mechanical information required to understand the construction and operation of the automobile.

BURNING LIQUID FUEL.

By William Newton Best. Revised Edition. N. Y., U. P. C. Book Co., Inc., 1922. 341 pp., illus., diagrams, 9 x 6 in., cloth. $4.00.

This revised and enlarged edition of Dr. Best's book, formerly entitled the "Science of Burning Liquid Fuel", is a plain, straightforward summary of long practical experience in designing and erecting oil fuel installations. Specific information is given on the use of liquid fuel in many industries and on all the various forms of equipment. Drawings show how the equipment is applied to various purposes. The author discusses, among other topics, locomotive, stationary, marine and low-pressure boiler equipment; practice in foundries and forge shops; and equipment for the sugar, copper, ceramic, cement, baking, candy, and oil industries.

* Unless otherwise specified, books in this list have been donated by the publishers.

STEAM BOILER MAINTENANCE.

By Reg. Clayton. (Pitman's Technical Primers.) Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 118 pp., diagrams, 6 x 4 in., cloth. 85 cents.

This brief account of good practice is clearly written in language devoid of unnecessary technicalities. The author hopes it will illustrate how breakdowns may be avoided and maintenance costs reduced by systematic supervision. It is not intended to be a guide for firemen so much as to show the weak spots in the apparatus and to lead to the discovery and remedying of incipient defects and malpractices.

DIE PRESSLUFTWERKZEUGE.

By P. Iltis. Zweite, umgearbeitete Auflage. Berlin, Vereinigung Wissenschlaftlicher Verleger, 1921. (Sammlung Goschen.) 117 pp., illus., 6 x 4 in., cloth.

After a brief general and historical introduction, this little book treats of the application of compressed air to hammers, percussion drills, punching, stamping, and riveting machinery, drills, hoists, and blasting machines. Within its limits, a large amount of information is given on the practical uses of compressed air.

DIE WARMWASSERBEREITUNGS- UND VERSORGUNGSANLAGEN.

By Wilhelm Heepke. Zweite, umgeänderte und erweiterte Auflage. (Oldenbourgs technische Handbibliothek, Bd. 5.) München, R. Oldenbourg, 1921. 706 pp., diagrams, 9 x 6 in., paper. 120 marks.

This is an exhaustive treatise on the installation of hot-water plants, covering the subject in great detail. The subject-matter is confined to water-heating systems for domestic and industrial use. Methods of heating, boilers, piping, regulating, and measuring instruments, insulating, etc. are fully covered.

DEEP WELL DRILLING.

By Walter H. Jeffery. Toledo, Ohio, W. H. Jeffery Co., 1921. 531 pp., plates, illus., diagrams, tab., 9 x 6 in., cloth. $5.00.

The author has undertaken to cover the two methods most generally used, the cable tool and the hydraulic rotary, including the building of the derrick, drilling, handling casing, fishing lost tools, and the completion of the well, according to the best practice of the day. Supplementary chapters deal with oil and gas geology, cost of drilling, strength of materials, laws relating to gas and oil wells, and other general information of use to the driller.

MINERAL LAND SURVEYING.

By James Underhill. Third Edition, Revised. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 237 pp., diagrams, 8 x 5 in., cloth. $3.50.

The methods used at the present time in surveying and patenting mineral lands in the Western States are described, and the book is intended for mineral surveyors and students of mining engineering. Several additions have been made in this edition, especially in the treatment of the direct solar observation. The specimen field notes illustrating the requirements of the office of the United States Surveyor General for Colorado have been rewritten and represent present practice.

MANUFACTURE AND USES OF EXPLOSIVES.

By R. C. Farmer. (Technical Primer Series.) Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 116 pp., diagrams, 6 x 4 in., cloth. 85 cents.

Information on explosives is so scattered and so much concerned with the details of individual explosives, that some difficulty is experienced in obtaining a general view of the nature and functions of explosives. This work endeavors to provide this within a short compass, dealing first briefly with the historical development of explosives, and then with the manufacture and use of those most used to-day. A brief bibliography is included.

COAL CATALOG, COMBINED WITH COAL FIELD DIRECTORY, FOR 1922.

Pittsburgh, Keystone Consolidated Publishing Co. 1 350 pp., illus., 12 x 9 in., cloth. $10.00.

This encyclopedia and directory of the American coal industry gives a great deal of technical and commercial information of the kind needed by producers and users of coal. The first section discusses the geology of coal; the coal areas of the United States; and the preparation, storage, sampling and composition of coal. It gives a table showing the fusibility of coal ash by States and seams, a list of coke ovens, a list of coal exchanges and pools, with their mines, and a table of analyses of coal. Part 2 classifies coals according to rank, use, and structure. Part 3, lists the mines of the country, by States, giving their situations, officers, equipments, output, etc. The new edition has been thoroughly revised.

CHEMISTRY OF COLLOIDS.

By W. W. Taylor. Second Edition. Lond., Edward Arnold & Co.; N. Y., Longmans, Green and Co., 1921. 332 pp., diagrams, 7 x 5 in., cloth. $3.50.

This book is intended to meet the want of a convenient textbook and to serve as a reference work for workers in other sciences, who are interested in colloids. The author discusses the general properties of colloids, the methods of preparation, absorption, and the applications of colloid chemistry in dyeing, tanning, sewage purification, biology, etc.

HANDBOOK OF FIELD AND OFFICE PROBLEMS IN FOREST MENSURATION.

By Hugo Winkenwerder and Elias T. Clark. Second Edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 133 pp., tab., 8 x 5 in., fabrikoid. $2.00.

The authors present a series of carefully selected typical problems to be used as practical illustrations to supplement classroom work by students of forestry. Explicit directions regarding equipment and method of procedure are given in each case. The problems are of standard character and generally applicable throughout the country. The necessary data and tables, and a bibliography are appended.

THE FOREMAN AND HIS JOB.

By Charles R. Allen. Phila. and Lond., J. B. Lippincott Co., 1922. 526 pp., 8 x 5 in., cloth. $3.50.

This book has grown from the experience of the author in organizing and conducting conferences of foremen called to discuss matters that affect the efficiency of their work. The matter here presented deals with the problems that confront the foreman and suggests proper ways to deal with them. The book is intended for foremen and other minor executives and also for organizers of foremen's conferences, who will find it a suggestive guide in arranging programs.

INTRODUCTION TO THE THEORY OF RELATIVITY.

By L. Bolton. N. Y., E. P. Dutton and Co., 1921. 177 pp., 8 x 5 in., cloth. $2.00.

This is, to a large extent, Mr. Bolton's essay on "Relativity and Gravitation", which won the Eugéne Higgins prize, extended to some twelve times its length. The book forms a simple introduction to the new general theory of mathematical physics, showing that this develops easily and naturally out of the search for a general mode of statement of physical laws. The author has bent his efforts specially to making the reader understand the general drift of the principle of relativity, to realize what it is all about.

ÉTUDE GÉOMÉTRIQUE DES TRANSFORMATIONS BIRATIONNELLES

Et des Courbes Planes. By Henri Malet. Paris, Gauthier-Villars et Cie., 1921. 259 pp., diagrams, 10 x 7 in., paper. 32 francs.

A study, by synthetic methods, of birational transformations and plane curves. It strives particularly to establish the first principles and to set forth precisely, in logical and geometrical fashion, the conditions under which the homographic correspondence of laws is based. The author's exposition of modern geometry is based on the methods of Chasles and Poncelet.

LA THEORIE DE LA RELATIVITE ET SES APPLICATIONS A L'ASTRONOMIE.

By Emile Picard. Paris, Gauthier-Villars et Cie., 1922. 27 pp., paper.

In this little book the Permanent Secretary of the Académie des Sciences gives an interesting historical and critical sketch of the theory of relativity with reference to its astronomical applications.

INGENIEUR=MATHEMATIK.

By Heinz Egerer. Bd. 2. Berlin, Julius Springer, 1922. 713 pp., 9 x 6 in., cloth. 528 marks.

The author of this work has endeavored to present the subject in a manner that will give the engineer a thorough grounding in those branches which he will find useful in his work, and to enable him to think and feel mathematically in later years, when most mathematical formulas are forgotten. Vol. 1, on algebra, analysis, etc., appeared several years ago. The present volume treats of differential and integral calculus, series, curves, maxima, and minima. A third volume is in preparation.

SEWERS AND SEWERAGE.

By H. Gilbert Whyatt. (Pitman's Technical Primers.) Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 118 pp., diagrams, 6 x 4 in., cloth. 85 cents.

A brief guide illustrating accepted British practice in the design and construction of sewer systems.

SEWERAGE AND SEWAGE TREATMENT.

By Harold E. Babbitt. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 531 pp., illus., diagrams, tables, 9 x 6 in., cloth. $5.00.

The need for a book covering the entire field of sewerage and sewage treatment has led to the preparation of this work. The ground covered includes an exposition of principles and methods for designing, constructing, and maintaining sewerage works, and for treating sewage. Stress is laid on fundamentals rather than details of practice. The book presents simplified diagrams on the nomographic principle for solving Kutter's and other hydraulic formulas, and the results of original tests on leaping and overflow weirs.

LAND DRAINAGE.

By W. L. Powers and T. A. H. Teeter. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 270 pp., illus., 8 x 5 in., cloth. $2.75.

The authors, in this book, treat drainage from the agricultural point of view, developing the subject as a question of applied soil physics. They discuss field drainage, district drainage, tidal marshes, irrigated land drainage, and drainage surveying. The book is intended for agricultural engineers and farmers.

HANDBOOK OF ARCHITECTURAL PRACTICE.

Issued by the American Institute of Architects. Wash., Press of the American Institute of Architects. 204 pp., 11 x 9 in., cloth. $5.00.

This volume includes a collection of practices, intended as an aid to proper and efficient business administration. It will be useful to beginners as a guide and will prove suggestive to experienced architects, and owners will find it helpful in enabling them to co-operate intelligently with architects. Contents: The Architect and the Owner; The Architect's Office; Surveys, Preliminary Studies and Estimates, Working Drawings and Specifications; The Letting of Contracts; The Execution of the Work; The Architect and the Law; Documents of the American Institute of Architects.

MATERIALS OF CONSTRUCTION.

By Adelbert P. Mills. Second Edition. Edited by H. W. Hayward. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 9 sections, illus., 9 x 6 in., cloth. $4.00.

The author presents herein a general textbook covering the manufacture, properties, and uses of the common materials of construction concisely and in a modern manner. Plaster, lime, cement, clay products, metals, alloys, timber, rope and mechanical fabrics, are included. This edition has been revised and enlarged by condensing or enlarging certain chapters and adding several new ones.

DIE FLUSSMETALLE IM BRÜCKENBAU.

By E. J. Albrecht. Leipzig, Wilhelm Engelmann, 1914. 56 pp., illus., 11 x 7 in., cloth. (Gift of the Author.)

Dr. Albrecht's monograph is a concise history of the introduction of mild steel as a material for bridges, with some notes on the influence of steel on bridge design and construction. The introductory chapter gives an account of the development of iron making up to the introduction of the Bessemer and open-hearth processes. Chapter 2 records the introduction of steel bridges in different countries, the growth of testing methods, and the use of alloy steels.

HYDRO-ELECTRICAL ENGINEERING.

By Richard Muller. N. Y., G. E. Stechert & Co., 1921. 431 pp., diagrams, 10 x 7 in., cloth. $6.00.

This work is a systematic exposition of those principles of hydraulic and electrical engineering which underlie the design of hydro-electric plants. It is intended for engineers engaged in designing and constructing plants or reporting on their commercial possibilities. Contents: Hydrology; Stream Measurements; Canals; Pressure Pipes; Dams; Turbines; Power House and Sub-Station Equipment; Transmission Lines; Investigation of Water Power Projects; Economics; Description of Hydro-Electric Plants; Evaluation of Water Powers; Legislation.

WHARF MANAGEMENT, STEVEDORING, AND STORAGE.

By Roy S. MacElwee and Thomas R. Taylor. N. Y. and Lond., D. Appleton and Co., 1921. 350 pp., forms, diagrams, tab., 9 x 6 in., cloth. $5.00.

This, it is said, is the first book to deal comprehensively with wharf administration, the loading and unloading of cargoes, and the handling and storage of outward and inward freight. It describes the duties of pier superintendents, receiving clerks, tally men, and foremen of stevedores. Other chapters deal with wharf layout and construction, cargo-handling machinery, longshoremen, labor problems. Particular attention is given to the economic aspects of the subject.

MEMBERSHIP

(From February 1st to February 28th, 1922)

ADDITIONS

MEMBERS		Date of Membership.
ABE, MIKISCHI. 24 Mita South Temple St., Shiba-Ku, Tokyo, Japan.		Nov. 21, 1921
BARSTOW, EUGENE DUSTON. Cons. Engr.; Summit County San. Engr., Court House, Akron, Ohio..	Assoc. M. M.	Oct. 9, 1917 Jan. 20, 1922
BLUM, ARTHUR NORBERT. Chf. Engr. and Technical Adviser, Henry Disston & Sons, Inc. (Res., Delmar-Morris Apartments, Germantown), Philadelphia, Pa..........................		Jan. 16, 1922
BOLTON, JAMES. Cons. Engr., 1102 West Grace St., Richmond, Va.		Jan. 16, 1922
BUSH, WILLIAM HECTOR. Drainage Engr., Wabash Ry. System, 1467 Railway Exchange Bldg., St. Louis, Mo..............		Jan. 16, 1922
CHANDLER, EMERSON LAWRENCE. Asst. Div. Engr., The Miami Conservancy Dist., Dayton, Ohio.......	Jun. Assoc. M. M.	Nov. 8, 1909 Mar. 11, 1919 Jan. 20, 1922
CONSTANCE, EDWARD CARTWRIGHT. U. S. Asst. Engr., 707 Postal Telegraph Bldg., Kansas City, Mo...	Jun. Affiliate M.	Dec. 6, 1904 Feb. 5, 1907 Jan. 20, 1922
COUCH, EUGENE. Engr. of Structural Design, City Engr.'s Office, City Hall, Dallas, Tex...........................		Jan. 16, 1922
DUFOUR, FRANK OLIVER. Prof., Civ. Eng., and Director of Materials Testing Laboratories, Lafayette Coll., Easton, Pa............................	Jun. Assoc. M. M.	Dec. 5, 1899 Oct. 1, 1902 Jan. 20, 1922
EARLE, WILLIAM SLADE. Div. Engr., Florida State Road Dept., Box 36, Tallahassee, Fla..............................		Jan. 16, 1922
EDDY, HAROLD MANSFIELD. Lt.-Commander, C. E. C., U. S. N., U. S. Naval Air Station, Lakehurst, N. J..................................	Assoc. M. M.	Oct. 9, 1917 Jan. 20, 1922
FOSTER, WALTER LINDER. Associate Prof. of Civ. Eng., in Chg. of Railway Eng., Iowa State Coll., Ames, Iowa.................................	Assoc. M. M.	May 31, 1916 Jan. 20, 1922
HALL, WARD. Asst. Engr., California Railroad Comm., 952 Flood Bldg., San Francisco, Cal............	Assoc. M. M.	Dec. 3, 1913 Jan. 20, 1922
HOWSON, LOUIS RICHARD. (Alvord, Burdick & Howson), 8 South Dearborn St., Chicago (Res., 130 Eighth Ave., La Grange), Ill..............	Assoc. M. M.	Dec. 2, 1914 Jan. 20, 1922
JACQUES, HENRY LOUIS. Supt. of Constr., Los Angeles Public Service Comm., 728 Brand Boulevard, San Fernando, Calif........................	Assoc. M. M.	Dec. 6, 1915 Jan. 20, 1922
JONES, PERCY FRANCIS. Chf. Engr. and Supt., Modesto Irrig. Dist., Modesto, Cal......................	Assoc. M. M.	Feb. 4, 1914 Jan. 20, 1922
LAWRENCE, CHARLES WALTER. Prof., Civ. Eng., Univ. of Southern California, 1546 Fourth Ave., Los Angeles, Cal..............................	Assoc. M. M.	Jan. 8, 1908 Jan. 20, 1922
MARDÉL, CHARLES MARY. Chf. Engr., San Francisco-Sacramento R. R. and Nevada County Narrow Gauge R. R., 530 Fortieth St., Oakland, Cal....................................		Sept. 12, 1921

MEMBERS—(*Continued*)

		Date of Membership.
NOREN, GEORGE ALEXANDER. Engr. of Grade Crossings, N. Y. C. R. R., Grand Central Terminal (2526 Grand Concourse), New York City......	Assoc. M. M.	Aug. 31, 1915 Jan. 20, 1922
OESTERBLOM, ISAAC. With The Truscon Steel Co., Mercantile Bldg., Calcutta, India..		Nov. 21, 1921
PETIT, CHARLES WESLEY. County Surv. and Supt. of Highways for Ventura County, 317 Kalorama Rd., Ventura, Calif..........................	Assoc. M. M.	May 6, 1914 Jan. 20, 1922
ROHN, RALPH EARLE. Chf. Engr., Canton Bridge Co., 1117 Seventeenth St., N. W., Canton, Ohio......	Assoc. M. M.	Nov. 28, 1916 Jan. 20, 1922
SMITH, CLAIBORNE ELLIS. With Public Works Office, 11th Naval Dist., U. S. N., 4048 Swift Ave., East San Diego, Cal.........................	Assoc. M. M.	Dec. 5, 1911 Jan. 20, 1922
VON UNWERTH, HANS. Cons. Engr., 505 Finance Bldg., Kansas City, Mo..........................	Assoc. M. M.	May 6, 1903 Oct. 12, 1921
WAUGH, ERNEST JUDSON. Constr. Engr., Nevada California Power Co., and Southern Sierras Power Co., Riverside, Cal..........................	Assoc. M. M.	May 31, 1916 Jan. 20, 1922
WOOD, CHARLES FRANCIS. 127 Parkside Ave., Brooklyn, N. Y......		Nov. 21, 1921

ASSOCIATE MEMBERS

AUSTIN, HERBERT ASHFORD ROBERTSON. First Asst. Engr., City and County of Honolulu, 16 Kapiolani Bldg., Honolulu, Hawaii.................	Jun. Assoc. M.	April 17, 1917 Sept. 12, 1921
BAER, CARL TOEVS. Office Engr., Myers & Noyes, 2302 Park Row, Dallas, Tex..		Oct. 10, 1921
BURGE, HAROLD WARREN. Engr. and Estimator, Geo. A. Fuller Co., 404 Sweetser Bldg. (Res., 3238 Sycamore Rd.), Cleveland, Ohio..		Nov. 21, 1921
BURGESS, HAROLD THOMAS. Supt. of Constr., C. W. Blakeslee & Sons, 201 Fourth St., Meriden, Conn.......................		Nov. 21, 1921
JÁUREGUI, ISIDRO GABINO. Pozo del Rey 21, Santiago de Cuba, Cuba..		Jan. 16, 1922
LOSEE, JAMES ROBERT. Asst. Plant and Production Engr., Chevrolet Div., Gen. Motors Corporation, 444 Peterboro St., Detroit, Mich..		Sept. 21, 1921
McKEE, SAMUEL CLAIR. 670 Nesslewood Ave., Toledo, Ohio......		Jan. 16, 1922
O'LEARY, WARNER JOHN. Field Engr., Valuation Dept., S. P. Co., Room 1049, S. P. Bldg., San Francisco, Cal................		Jan. 16, 1922
ORR, MILAN KENTON. Owner and Mgr., M. K. Orr Contr. Co., Harrison, Ark..		Jan. 16, 1922
REAGAN, CODY SYLVESTER. With Myers & Noyes, 1107 Dallas County Bank Bldg., Dallas, Tex............................		Oct. 10, 1921
SCHWINN, FREDERICK SIEVERS. Chf. Engr., I. & G. N. Ry., 725 Mason Bldg., Houston, Tex..		Nov. 21, 1921
TILLOTSON, ELBERT SAUNDERS. Chf. Estimator, The Austin Co., 1026 Bulletin Bldg., Philadelphia, Pa..................................	Jun. Assoc. M.	Nov. 26, 1918 Nov. 21, 1921
WATT, ROBER FARQUHAR. Care, Froehlich & Emery Eng. Co., Book Bldg., Detroit, Mich..........	Jun. Assoc. M.	Sept. 10, 1918 Sept. 12, 1921
WHITAKER, LAURENCE EDWIN. 1985 Geddes Ave., Ann Arbor, Mich.		Jan. 16, 1922

JUNIORS	Date of Membership.
HARDING, JAMES CLARKE, JR. San. Engr., Fuller & McClintock. 107 Broadway, New York City (Res., 405 Gramatan Ave., Mount Vernon, N. Y.)	Nov. 21, 1921
PERKINS, JOHN MACKLEM. Langhorne, Pa.	Jan. 16, 1922
RIDER, EDWIN BERNARD. 4912 Alhambra Ave., Govans, Baltimore, Md.	Sept. 12, 1921
ROBERTSON, WALTER HARRISON. Supt. of Plant, Lock Joint Pipe Co., Ampere (Res., 77 Stockton Pl., East Orange), N. J.	Jan. 16, 1922
TERRY, CHARLES LE PATOUREL. 115 Pitt St., Sydney, New South Wales, Australia	Nov. 21, 1921

RESIGNATIONS

MEMBERS	Date of Resignation.
MYERS, CHARLES HAYWARD	Feb. 14, 1922
WORTHINGTON, CHARLES	Feb. 14, 1922
ASSOCIATE MEMBERS	
CHAPMAN, VERNI JAY	Feb. 14, 1922
KINNEAR, LAWRENCE WILSON	Feb. 14, 1922
SIGMUND, BENJAMIN JOSEPH	Feb. 14, 1922
TOWLE, FREEMAN EUGENE	Dec. 31, 1921
WIGHOLM, CARL AUGUST	Feb. 14, 1923

DEATHS

ANNAN, CHARLES LE ROY. Elected Member, July 4th, 1888; date of death unknown.

CLEMENT, FRANK HUDSON. Elected Member, November 1st, 1882; died February 18th, 1922.

DAILEY, JOHN ALEXANDER. Elected Affiliate, September 7th, 1904; died February 9th, 1922.

FORCE, CYRUS GILDERSLEEVE. Elected Member, February 6th, 1878; died February 7th, 1922.

MERRILL, WILLIAM FESSENDEN. Elected Member, April 1st, 1874; died February 3d, 1922.

SCHWENDENER, KARL DEWITT. Elected Associate Member, April 1st, 1914; Member, November 25th, 1919; died January 23d, 1922.

STANTON, ROBERT BREWSTER. Elected Member, September 1st, 1880; died February 23d, 1922.

Total Membership of the Society, February 28th, 1922, 10 275.

CURRENT CIVIL ENGINEERING LITERATURE

Note.—The title of this list has been changed from "Monthly List of Recent Engineering Articles of Interest" to that given above. At the same time the number of periodicals indexed has been curtailed. This has been accomplished by excluding all periodicals which are published distinctly in the interest of other branches of engineering. It is the intention to index practically all the articles in the publications listed.

A new form of classification has been adopted, which will be expanded as necessary. The same letters and numbers will always be used to indicate the same classes and subdivisions of classes, and therefore any one wishing to group the articles listed on a certain subject will find them in each Number of Proceedings under the same letter and number.

KEY TO ABBREVIATED REFERENCES TO PUBLICATIONS INDEXED*

Abbreviated References.	Publication.	Place.
Am. C. Inst.	*American Concrete Institute* (Y.)	Detroit
A. I. E. E.	*American Institute of Electrical Engineers, Journal* (M.)	New York
A. R. E. A.	*American Railway Engineering Association* (Y.)	Chicago
A. S. T. M.	*American Society for Testing Materials, Proceedings* (Y.)	Philadelphia
Am. Soc. C. E.	*American Society of Civil Engineers, Proceedings* (M.)	New York
Am. Soc. Mun. Impvts.	*American Society for Municipal Improvements* (Y.)	New York
Am. W. W. Assoc.	*American Waterworks Association, Journal* (Bi-M.)	Baltimore
Am. Wood Prs. Assoc.	*American Wood Preservers Association* (Y.)	Baltimore
Ann. P. et C.	*Annales des Ponts et Chaussées* (Bi-M.)	Paris
Ann. T. P. Belg.	*Annales des Travaux Publics de Belgique* (Bi-M.)	Brussels
Assoc. Ing. Gand	*Association des Ingénieurs sortis des Ecoles Spéciales de Gand* (Q.)	Ghent
Bost. Soc. C. E.	*Boston Society of Civil Engineers, Journal* (M.)	Boston
Can. Engr.	*Canadian Engineer* (W.)	Toronto
Cem. Eng.	*Cement and Engineering News* (M.)	Chicago
Cornell C. E.	*Cornell Civil Engineer* (M.)	Ithaca
Dock & Harbor	*Dock and Harbor Authority* (M.)	London
Eisenbau	*Der Eisenbau* (M.)	Leipsig
Eng.	*Engineering* (W.)	London
Eng. Club, St. L.	*Engineers Club, St. Louis, Journal* (Bi-M.)	St. Louis
Eng. & Contr.	*Engineering and Contracting* (W.)	Chicago
Eng. Inst. Can.	*Engineering Institute of Canada, Journal* (M.)	Montreal
Eng. N. R.	*Engineering News-Record* (W.)	New York
Eng. Soc. Pa.	*Engineers' Society of Pennsylvania* (M.)	Harrisburg
Eng. Soc. W. Pa.	*Engineers' Society of Western Pennsylvania, Journal* (M.)	Pittsburgh
Engr.	*Engineer* (W.)	London
Engrs. & Eng.	*Engineers and Engineering, Engineers' Club of Philadelphia* (M.)	Philadelphia
Gen. Civ.	*Le Génie Civil* (W.)	Paris
Gesund. Ing.	*Gesundheits Ingenieur* (W.)	Munich
Inst. C. E.	*Institution of Civil Engineers* (Q.)	London
Inst. Mun. & Co. Engrs.	*Institution of Municipal and County Engineers* (W.)	London
Int. Ry. Assoc.	*International Railway Association, Bulletin* (M.)	Brussels
Land. Arch.	*Landscape Architecture* (M.)	Harrisburg
Mech. Eng.	*Mechanical Engineering* (M.) *Journal of the American Society of Mechanical Engineers*	New York
Mil. Engr.	*Military Engineer* (M.)	Washington
Min. & Metal.	*Mining and Metallurgy* (M.) *American Institute of Mining Engineers*	New York
Mun. & Co. Eng.	*Municipal and County Engineering* (M.)	Indianapolis
N. E. W. W. Assoc.	*New England Water Works Association* (M.)	Boston
N. Y. R. R. Club	*New York Railroad Club* (M.)	Brooklyn
Oest. Ing. Arch. Ver.	*Oesterreichischer Ingenieur and Architekten Verein, Zeitschrift* (W.)	Vienna
Power	*Power* (W.)	New York
Rev. Gen.	*Revue Générale des Chemins de Fer* (M.)	Paris
Ry. Age	*Railway Age* (W.)	New York
Ry. Main. Engr.	*Railway Maintenance Engineer* (M.)	Chicago
Ry. Rev.	*Railway Review* (W.)	Chicago

* Y = Yearly ; Q = Quarterly ; M = Monthly ; F = Fortnightly ; W = Weekly.

Abbreviated References.	Publication.	Place.
Schw. Bauz	*Schweizerische Bauzeitung* (W.)	Zurich
Sci. Am	*Scientific American* (M.)	New York
Soc. Ing. Civ. Fr	*Société des Ingénieurs Civils de France, Mémoires et Comptes Rendus* (Q.)	Paris
Ver. deu. Ing	*Verein deutscher Ingenieure, Zeitschrift* (W.)	Berlin
West. Ry. Club	*Western Railway Club* (M.)	Chicago
West. Soc. Engrs	*Western Society of Engineers* (M.)	Chicago
Zeit. Bau	*Zeitschrift fur Bauwescn* (Q.)	Berlin
Z. d. Bauver	*Zentralblatt der Bauverwaltung* (Semi-Weekly)	Berlin

A. Applied Sciences

a. Processes of Calculation

1. Mechanical Processes

Appareil Permettant le Tracé des Trois Coniques, d'un Mouvement continu Automatique.* (Apparatus for Drawing the Three Conic Sections, with a Continuous Automatic Movement.) Gen. Civ. Dec. 17, '21.

Appareils de Mesures à Aiguilles et Graduations Curvilignes, Système Dugit.* (Measuring Instruments with Pointers and Curvilinear Graduations.) Augustin Dumont. Gen. Civ. Jan. 7, '22.

2. Graphical and Nomographical Processes

Surfaces Cerclées et Surfaces de Révolution.* (Circular Surfaces and Surfaces of Revolution.) M. Stuyvaert. Assoc. Ing. Gand. Pt. 3, '21.

Détermination Graphique des Moments Fléchissants Maxima dans une Poutre Supportant des Charges Mobiles par l'Intermédiare des Traverses.* (Graphical Determination of the Maximum Bending Moment in a Beam Supporting Moving Loads by Means of Cross-Beams.) Smoukovitch et Barbillion. Gen. Civ. Dec. 17, '21.

3. Stresses and Strains

Reminders for the Designer of Steel Structures.* R. Fleming. Eng. N. R. Feb. 16, '22.

B. Applied Mechanics

a. Mechanics of Solids (Strength of Materials)

2. Elastic Solids

The Fatigue of Metals Under Repeated Stress.* H. F. Moore and J. B. Kommers. (From *Bulletin No. 124*, Univ. of Illinois.) Eng. Contr. Dec. 28, '21.

Alternating-Stress Fatigue Restricted to High Stresses.* Eng. N. R. Jan. 12, '22.

Ueber das Gleichgewicht von rechteckigen und elliptischen Platten unter einer Einzellast.* (On the Equilibrium of Right Angled and Elliptical Plates Under Single Load.) Hans Happel. Eisenbau May, '21.

Ueber die Stabilität versteifter Platten.* (The Stability of Braced Plates.) S. Timoschenko. Eisenbau May, '21.

Nochmals über die Biegungsbeanspruchung von U-Eisen.* (Further discussion on the Bending Stress of U-Iron.) Eisenbau Aug., '21.

Beitrag zur Berechnung der Spannungen in Augenstäben.* (Contribution to the Calculation of Tensions in Eye-Bars.) Josef Beke. Eisenbau Sept., '21.

Prüfung von Druckstäben für Brücken des Kaiser-Wilhelm-Kanals.* (Testing Compression Members for Bridges Across the Kaiser Wilhelm Canal.) Fr. Voss. Z. d. Bauver. Jan. 14, '22.

Die Knickfestigkeit vollwandiger Stäbe in neuer einheitlicher Darstellung.* (The Resistance to Buckling of Plain Bars Presented in a New and Uniform Way.) H. Zimmermann. Z. d. Bauver. Jan. 21, '22.

Versuche an Gelochten Zugstäben aus Gummi.* (Experiments with Perforated Rubber Bars.) A. Leon. Eisenbau Sept., '21.

Zusatspannungen bei Gewölben.* (Extra Tension in Arches.) Walter Nakonz. Zeit Bau. Pt. 10, '20.

Biegungslinien ringförmiger Träger.* (Deflection Curves of Annular Beams.) Friedrich Düsterbehn. Eisenbau Oct., '21.

Ueber die Querknickung gleichmässig gedrückter Kreisringe.* (Transverse Bending of a Circular Ring Under Uniform Pressure.) Karl Federhofer. Eisenbau Nov., '21.

Ueber die Drehungsbeanspruchung von dünnwandigen symmetrischen U-förmigen Querschnitten.* (On the Torsional Stress of Thin-Walled Symmetrical U-Shaped Sections.) A. Eggenschwyler. Eisenbau Aug., '21.

Berechnung statisch unbestimmter Systeme mittels der "Deformationsmethode.* (Calculation of Static Indeterminate Systems by the "Deformation Method".) A. Ostenfeld. Eisenbau Nov., '21.

4. Riveted Systems

Note sur la Théorie Physique de la Résistance des Pièces Comprimées à Treillis, par Gustave L. Gérard.—Id. Note Additionnelle.—Revue Universelle des Mines 1913–1914. (Note on the Physical Theory of the Resistance of Compressed Lattice Pieces by Gustave L Gérard—Id. Additional Note.—Revue Universelle des Mines, 1913–1914.) F. Keelhoff. Assoc. Ing. Gand. Pt. 3, '21.

Die Berechnung der Rahmengebilde.* (The Calculation of Frame Structures.) A. Hertwig. Eisenbau May, '21.

5. Homogeneous Inelastic Solids

Culvert Pipe Load Investigation. Eng. N. R. Jan. 12, '22.

6. Heterogeneous Solids (Reinforced Materials)

Utilisation de la Règle a Calcul Ordinaire (types Mannheim et Similaires) pour le Calcul Rapide des Pièces Minces en Béton Armé.* (Use of the Ordinary Slide Rule (Mannheim and Similar Types) for the Rapid Calculation of Thin Reinforced Concrete Pieces.) R. Deguillaume. Gen. Civ. Dec. 17, '21.

7. Pulverulent Masses (Earth Pressure)

Measured Retaining-Wall Pressure from Sand and Surcharge.* Jacob Feld. Eng. N. R. Jan. 19, '22.

Neue Untersuchungen zur Erddrucktheorie.* (New Investigations on the Earth Pressure Theory.) Albert Freund. Zeit. Bau. Pt. 1, '21.

b. Hydraulics

1. Processes of Measurement

Die Grunlagen der Allgemeinen Abflussformel $v = A. R^b. J^c$.* (The Bases of the general drainage formula $v = A. R^b. J^c$.) Krey. Z. d. Bauver. Jan. 4, '22.

2. Physical Hydraulics (Orifices, Pipes, Channels, Waves)

Flow of Water Through Spiral Riveted Steel Pipe. (From *Bulletin* of Eng. Experiment Station of Purdue Univ.) Eng. Contr. Jan. 11, '22.

Kutter's Formula Simplified.* H. E. Babbitt. Eng. Contr. Feb. 8, '22.

Die Trugschlüsse aus den Mississippi-Messungen von Humphreys und Abbot und der fehlerhafte Bau der Ganguillet-Kutterschen Formel.* (The False Conclusions from the Mississippi Measurements of Humphreys and Abbot and the Incorrect Construction of the Ganguillet-Kutter Formula.) Beyerhaus. Z. d. Bauver. Apr. 2, '21.

Ueber die Bewegung des Wassers in künstlichen und natürlichen Gerinnen.* (The Movement of Water in Artificial and Natural Channels.) Josef Putzinger. Oest. Ing. Arch. Ver. Jan. 6, '22.

3. Industrial Hydraulics (Hydraulic Motors, Water Power, Transmission of Water Under Pressure, Propelling and Elevating Machinery)

The Scar House Hydro-Electric Installation.* Engr. Dec. 16, '21.

Automatic Hydro-Electric Generating Stations.* Dorville Libby, Jr. (From *Tech. Engineering News.*) Eng. Contr. Jan. 11, '22.

Draft-Tube Back Pressure Cured at Roosevelt Power Plant.* C. C. Cragin. Eng. N. R. Jan. 12, '22.

St. Lawrence Navigation and Power Investigation.* Can. Engr. Jan. 17, '22.

A Combined Hydro and Semi-Diesel Plant at Minnedosa, Manitoba.* Power Jan. 17, '22.

First Unit for Queenstown-Chippewa Water Power Plant Opened.* Eng. N. R. Jan. 19, '22.

Hydro-Electric Developments near Bathurst, N. B.* James Dick. Can. Engr. Jan. 31, '22.

Increasing Capacity of Parnahyba Plant.* H. P. Quick. Power Feb. 7, '22.

Moving Niagara Into Canada.* J. F. Springer. Sci. Am. Mar., '22.

Einiges über den Ausbau der Bayrischen Grosswasserkräfte und deren Nutzung. (On the Development of Bavarian Large Water Powers and Their Utilization.) E. Engelmann. Oest. Ing. Arch. Ver. Serial beginning Jan. 6, '22.

Ueber die Wirtschaftlichkeit von Druckschächten.* (The Economy of Pressure Shafts) Franz Kuhn. Oest. Ing. Arch. Ver. Jan. 6, '22.

c. Pneumatics

2. Physical Pneumatics (Flow of Gases, Waves. Air Resistance, Action of the Wind)

Luftverflüssigung und Lufttrennung.* (Liquefying and Separating Air.) Richard Linde. Ver. deu. Ing. Dec. 24, '21.

3. Industrial Pneumatics (Wind Mills, Transmissions by Compressed Air, Blowers, Compressers, Propulsive and Elevating Machinery)

Code for Displacement Compressors and Blowers. Mech. Eng. Jan., '22.

Neuzeitliche Kolbenkompressoren.* (Modern Piston Compressors.) P. Ostertag. Ver. deu. Ing. Dec. 24, '21.

Turbokompressoren und-gebläse.* (Turbo-Compressors and Blowers.) H. Baer. Ver. deu. Ing. Dec. 24, '21.

C. Materials of Construction and General Processes

a. Lime, Cement, Mortar, Concrete, Brick, Bitumen, etc.

A New Sand and Gravel Washing Plant Well Planned and Carefully Executed. Cem. Eng. Jan., '22.

Quick Hardening Cement Developed by the French. Cem. Eng. Jan., '22.

Test of Central Plant Mixed Concrete for Maximum Safe Haul.* Eng. Contr. Feb. 1, '22.

Tests on Absorptive Qualities of Concrete Blocks.* Stanton Walker. Eng. N. R. Feb. 16, '22.

Expériences sur le Retrait du Béton pendant le Durcissement.* (Experiment Upon the Shrinkage of Concrete During Setting.) G. Magnel. Assoc. Ing. Gand. Pt. 3, '21.

Ueber Versuche mit Steinerhaltungs-Mitteln.* (Experiments with Methods for Preserving Stone.) F. Rathgen. Zeit. Bau. Pt. 4, '20.

b. Metals

Motor Truck Haulage on 750 000 Cubic Yds. Rock Excavation Job.* Eng. Contr. Jan. 18, '22.

e. Earthwork—Cubage—Excavating Machinery

Comparison of Electric and Steam Draglines at Miami.* G. L. Teeple. Eng. N. R. Jan. 19, '22.

f. Rock Excavation—Mining—Rock Removal

Abstracts of Institute Papers to be Presented at New York Meeting Feb. 20–23, '22. Min. & Metal. Feb., '22.

Fire Prevention and Fighting in Metal Mines. H. M. Wolflin. Min. & Metal. Feb., '22.

Nouveaux Appareils Respiratoires de Sauvetage pour les Mines.* (New Rescue Respiratory Apparatus for Mines.) Gen. Civ. Dec. 24, '21.

g. Execution of Works. Specifications

1. Of Masonry

Process Charts and Their Place in Management.* Frank B. Gilbreth and L. M. Gilbreth. Mech. Eng. Jan., '22.

2. Of Concrete

Hollow Wall Concrete Construction.* Cem. Eng. Jan., '22.
Practical Side of Cold Weather Concreting.* Turner Construction Co. of New York. Eng. Contr. Jan. 25, '22.
Two Recent Methods for Proportioning Concrete.* H. H. Scofield. Cem. Eng. Feb., '22.
Cold Weather Concreting Methods and Equipment.* Eng. N. R. Feb. 2, '22.

5. Of Reinforced Concrete

On the Question of Reinforced Concrete.* P. M. Bülow. Int. Ry. Assoc. Jan., '22.
Large Reinforced Concrete Covered Reservoir.* Cem. Eng. Feb., '22.
Le Béton Armé et le "Ciment Fondu" Construction des Ouvrages en Béton Armé à Grande Portée.* (Reinforced Concrete and "Cast Cement" Construction of Long Span Structures of Reinforced Concrete.) Gen. Civ. Jan. 28, '22.

h. Foundations

Removing Concrete Foundations by Blasting.* Charles B. Spicer. (From *The Hercules Mixer*). Eng. Contr. Jan. 25, '22.
Columns and Walls Lifted by Swelling Clay Under Floor.* F. E. Giesecke. Eng. N. R. Feb. 2, '22.

i. Coffer-dams

Palplanches Métalliques Utilisées à la Reconstruction des Ponts de Chemin de Fer sur la Meuse, Détruits Pendant la Guerre.* (Metallic Sheet Piling Used in the Reconstruction of the Railroad Bridges Over the Meuse, Destroyed During the War.) M. Claise. Ann. P. et C. Sept.–Oct., '21.

x. Miscellaneous

Suggestions for Care and Operation of Wire Rope. James F. Howe. Cem. Eng. Jan., '22.

D. Highways

c. Construction

A Drainage Expert's Ideas on Highway Construction.* Edgar A. Rossiter. Mun. & Co. Eng. Jan., '22.
Constructing Standard Types of Asphalt Pavements.* W. L. Hempelmann. Min. & Co. Eng. Jan., '22.
Dense Asphalt Concrete Pavement Specifications. J. W. Howard. Mun. & Co. Eng. Jan., '22.
The "Rutting" and "Rolling" of Asphalt Pavements. Hugh W. Skidmore. Mun. & Co. Engr. Jan., '22.
Important Considerations in Reconstructing City Pavements.* Harlan H. Edwards. Mun. & Co. Eng. Jan., '22.
Constructing Kentucky Rock Asphalt Pavement on Dixie Highway Between Louisville and West Point, Kentucky.* J. H. Cahill. Mun. & Co. Eng. Jan., '22.
Highway Construction in Massachusetts.* Arthur W. Dean. Bost. Soc. C. E. Jan., '22.
Methods and Equipment Employed in Building Concrete Roadway on Mugegon-Grand Rapids, Mich., Turnpike.* C. E. Foster. Mun. & Co. Eng. Jan., '22.
Advantages of Hydrated Lime in Paving Concrete. Tyrrell B. Shertzer. Can. Engr. Jan. 3, '22.
Methods of Lighting Concrete Road Construction at Night.* R. I. Bernath. Eng. Contr. Jan. 4, '22.
Data on Truck Operations and Construction Costs of Concrete Pavement in Sioux County, Iowa.* Thos. J. Lough. Eng. Contr. Jan. 4, '22.
Special Methods in Using Slag in Concrete Roads.* Eng. N. R. Jan. 12, '22.
Paving Slab and Subgrade Studies in Illinois.* Clifford Older. (Abstract of paper read before State Highway Officials Assoc.) Eng. N. R. Jan. 12, '22.
The Use of Bitumen in Road Construction. E. W. A. Carter. Inst. Mun. & Co. Engrs. Jan. 14, '22.
Asphalt Paving at Bristol. Lessel S. McKenzie. Inst. Mun. & Co. Engrs. Jan. 14, '22.
Factors Determining the Selection of Pavements for Streets. C. M. Pinckney. (Paper read before City Paving Conference.) Can. Engr. Jan. 17, '22.
The Road Problem: Impressions of a Visit to America. A. Dryland. Inst. Mun. & Co. Engrs. Jan. 28, '22.
Using the Standardized Paving Brick. W. W. Horner. (Paper read before Am. Road Builders' Assoc.) Mun. & Co. Eng. Feb., '22.
Recent Developments in Pavement Construction Details. Charles M. Upham. (Paper read before Am. Assoc. of State Highway Officials.) Mun. & Co. Eng. Feb., '22.
Standard Specifications for Mineral Aggregates for Asphalt Pavements. Roy M. Green. (Paper read before Good Roads Congress.) Eng. Contr. Feb. 1, '22.
Construction Features of Oklahoma Federal Aid Project.* Eng. Contr. Feb. 1, '22.
Preparing Bituminous Gravel and Sand Roads. W. D. Sohier. (Paper read before Can. Good Roads Assoc.) Can. Engr. Feb. 7, '22.
The Structural Design of Pavements.* A. T. Goldbeck. Can. Engr. Feb. 14, '22.
"Rolled Base" Endorsed for Brick Road Construction. Eng. N. R. Feb. 16, '22.

d. Maintenance

12 Years' Experience with Bituminous Penetration Work on Kansas City Boulevards and Park Roads.* Fred Gableman. Eng. N. R. Jan. 12, '22.
A Maintenance Department, Its Financing, Organization and Operation (Highways). W. A. Van Duzer. Can. Engr. Jan. 24, '22.

d. Maintenance—(*Continued*)

Highways Repair and Maintenance in South Devon. A. Warren. Inst. Mun. & Co. Engrs. Jan. 28, '22.

Overcoming Cracking and Expansion Joint Troubles in Lucas County, Ohio, Concrete Roads.* E. D. Keil. Mun. & Co. Eng. Feb., '22.

g. Machinery and Tools

New Portable Mixing Plant for Repairing, Resurfacing and Laying Bituminous Pavements.* Monroe L. Patzig. Mun. & Co. Eng. Jan., '22.

Multiple-Batch Charging Plant for Truck Haulage.* Eng. N. R. Jan. 12, '22.

h. Vehicles—Automobiles

Developing a Highway Transportation System for a State.* A. R. Hirst. West. Soc. Engrs. Jan., '22.

Connecticut Makes Detailed Study of Highway Traffic.* Eng. N. R. Jan. 12, '22.

Handling Traffic During Highway Construction. Paul D. Sargent. Eng. N. R. Jan. 12, '22.

Untangling Our Traffic Tangles.* John A. Harriss. Sci. Am. Feb., '22.

x. Miscellaneous

Safety and Beauty as Factors in Road Design. A. R. Hirst. (Paper read before Am. Assoc. of State Highways Officials.) Eng. Contr. Jan. 4, '22.

Relation Between Molded and Core Concrete Specimens.* H. S. Mattimore. Eng. N. R. Jan. 12, '22.

Commercial and Technical Developments in the Asphalt Paving and Bituminous Road Fields. Eng. N. R. Jan. 12, '22.

The Status of Highway Research. W. K. Hatt. Eng. N. R. Jan. 12, '22.

Road Builders' Convention Stresses Financial and Administrative Sides of Highway Work. Eng. N. R. Jan. 26, '22.

Co-operation is Keynote of New Federal Highway Bill.* Thos. H. MacDonald. (Abstract of address given before Am. Assoc. of State Highway Officials.) Eng. N. R. Jan. 26, '22.

Recent Developments in the Highway Field.* (Abstracts of papers read before Good Roads Congress.) Eng. Contr. Feb. 1, '22.

Road Builders' Problems Discussed at Convention. (Abstracts of papers read before Am. Road Builders' Assoc.) Eng. N. R. Feb. 2, '22.

E. Bridges, Viaducts and Arches

b. Iron or Steel Bridges and Viaducts

Limits of Safety to Allow for Stresses in the Metallic Superstructure of Railway Bridges.* Albert Ronsse. Int. Ry. Assoc. Dec., '21.

Proposed Cantilever Bridge at Sydney, New South Wales.* Eng. Dec. 30, '21.

Sydney Harbor Cantilever Bridge Design. Eng. N. R. Jan. 12, '22.

Pilot Method of Erecting Steel Girds for Canadian Bridge.* Eng. Contr. Jan. 25. '22.

Erection of Hurricane Gulch Arch Bridge in Alaska.* E. G. Amesbury, Eng. N. R. Jan. 26, '22.

Open-Well Piers and Subdivided Warren Trusses of Bismarck-Mandan Bridge.* C. A. P. Turner. Eng. N. R. Feb. 2, '22.

New Road Bridge Opened Over Sixteen Mile Creek.* T. D. Mylrea. Can. Engr. Feb. 7, '22.

Die Wiederherstellung der Dünabrücke bei Riga.* (Restoration of the Düna Bridge at Riga.) Gaber. Zeit. Bau. Pt. 7–9, '20.

Brückenwiederherstellungen in Galizien.* (Restoration of bridges in Galicia.) Gaber. Zeit. Bau. Pt. 7, '20.

Ausbesserung der Auflagerknotenpunkte der Stadtbahnbrücke über die Spree beim Bahnof Bellevue in Berlin.* (The Repairing of the Points of Support of the Street Railway Bridge Over the Spree at the Bellevue Station in Berlin.) Kuhnke. Z. d. Bauver. Apr. 16, '21.

Der Umbau der Maasbrücke bei Anchamps durch die Maschinenfabrik Augsburg-Nürnberg A.-G., Werk Gustavsburg.* (Rebuilding of the Maas Bridge at Anchamps by the Gustavsburg Plant of the Augsburg-Nürnberg Machine Works A.-G.) Eisenbau Dec., '21.

Die Wiederherstellung der zerstörten Strassenbrücken über den Olt bei Slatina und uber den Oltetul bei Balsu in Rumänien.* (Reconstruction of the Destroyed Highway Bridges Over the Olt at Statina and Over the Oltetul at Balsu in Rumania.) Z. d. Bauver. Jan. 22, '21.

Die eiserne Ueberbauten der Centovalli-Bahn, Ferrovia Locarno-Domodossola.* (The Iron Superstructures of the Centovalli Road, Ferrovia Locarno-Domodossola.) P. Sturzenegger. Schw. Bauz, Serial beginning Jan. 7, '22.

c. Stone Bridges and Viaducts

Die Southwark-Brücke in London.* (The Southwark Bridge in London.) Eisenbau Aug., '21.

d. Concrete and Reinforced Concrete Bridges and Viaducts

Concrete Bridge Construction in Winter.* Norman M. Stineman. Eng. Contr. Dec. 28, '21.

Collapse of Palm Beach Concrete Arch Bridge.* Eng. N. R. Jan. 26, '22.

Some Features of the Chemung River Concrete Bridge.* Eng. N. R. Feb. 2, '22.

Note sur la Reconstructión du Pont de Brasles, sur la Marne, près de Château-Thierry.* (Note on the Reconstruction of the Brasles Bridge, Over the Marne, Near Château-Thierry.) M. Delforges. Sept.–Oct., '21.

Procédé de Construction, sans Cintres, des Grands Arcs en Béton Armé. (Process for Constructing, Without Centers, Large Reinforced Concrete Arches.) Ch. Dantiu. Gen. Civ. Jan. 14, '22.

e. Centerings. Scaffolds

Renewing a Bridge Without Falsework.* A. B. Corthell. Ry. Main. Engr. Jan., '22.

f. Suspension Bridges. Transfer Bridges

Bridging the Detroit River.* Sci. Am. Feb., '22.
Der Windverband von Hängebrücken sehr grosser Spannweiten.* (Wind-Bracing of Very Long Span Suspension Bridges.) W. Schachenmeier. Eisenbau May, '21.

g. Swing, Bascule, Lift, Floating, Oscillating Bridges; Traveling Cranes

The Wells Street Bridge.* Thomas Pihlfeldt. West. Soc. Engrs. Feb., '22.
Failure of St. Mary's Bascule Bridge.* August Kuhlmann. Sci. Am. Mar., '22.

h. Tests, etc.

British Impact Measurements Analyzed.* F. E. Turneaure. Eng. N. R. Jan. 19, '22.
Economics of Military Bridging. P. S. Bond. Mil. Engr. Jan.–Feb., '22.

x. Miscellaneous

Economy and Efficiency in Modern Highway Bridge Building. Howard W. Holmes. Eng. N. R. Feb. 16, '22.

F. Inland Waters

a. Natural Waterways (General Articles)

St. Lawrence Navigation and Power Investigation.* Can. Engr. Jan. 17, '22.
Why the Joint Commission Favors the St. Lawrence Waterway. Eng. N. R. Feb. 2, '22.
Binnenschiffahrtswege im nordamerikanischen Osten.* (Internal Navigation Routes in Eastern North America.) Schw. Bauz. Nov. 26, '21.

b. Canals (General Articles)

Die Kanalanlagen bei Hannover.* (The Canal Works at Hanover.) Progasky. Zeit. Bau. Pt. 4, '20.
Beseitigung der Kreuzermole und der Binnenhafenkaimauer vor den neuen Ostseeschleusen des Kaiser-Wilhelm-Kanals.* (Removal of the Cruiser Pier and the Quay Wall of the Inner Harbor in Front of the New Baltic Locks of the Kaiser Wilhelm Canal.) Lohmeyer. Zeit. Bau. Pt. 4, '21.
Die Bauten des Ems-Weser-Kanals in der Weserniederung bei Minden i. W.* (The Construction of the Ems-Weser Canal in the Weser Low-lands Near Minden.) Zeit. Bau. serial beginning Pt. 7, '21.

c. Regulation of Waterways, Volume of Discharge, Freshets, Floods, Soundings.

Proposed Regulation of Lake Ontario.* Can. Engr. Dec. 29, '21.
Flood Measures in the Vicinity of Dayton, Ohio.* Arthur E. Morgan. West. Soc. Engrs. Jan., '22.
Solving the Problem of St. Lawrence Navigation. Chas. P. Loveland. Can. Engr. Jan. 31, '22.
Progress on Flood Prevention at Phoenix, Ariz.* Eng. N. R. Jan. 26, '22.

e. Locks, Lifts, Elevators, Inclined Planes

Verwendung von Hebern im Schleusenbetrieb.* (The Use of Siphons in the Operation of Locks.) Gröhe. Zeit. Bau. Pt. 10, '21.

g. Consolidation of Banks, Leakage, Maintenance of Channel, Dredging

Methods and Cost of Thawing Frozen Gravel by Means of Cold Water.* Edward E. Pearce. (From *Mining and Scientific Press.*) Eng. Contr. Feb. 15, '22.
Entsandungsanlagen nach Patent H. Dufour.* (Sand-Removing Apparatus According to the H. Dufour Patent.) P. Niethammer. Schw. Bauz. serial beginning Dec. 17, '21.

j. River Ports, Equipment

The Possibilities of Detroit as a World Port.* William H. Adams. Dock and Harbour Feb., '22.

k. Utilization of Inland Waterways, Freight, Capacity

Wirtschaftliche Untersuchungen über die Abmessungen neuer Hauptwasserstrassen und der auf ihnen verkehrenden Fahrzeuge. (Economic investigations on the Dimensions of New Main Waterways and of the Vessels Using Them.) Momber. Zeit. Bau. Pt. 7, '21.
Schiffahrt auf dem Oberrhein.* (Navigation on the Upper Rhine.) Schw. Bauz. Jan. 14, '22.

G. Mar'time Works

c. Vessels and Maritime Navigation, Lighthouses and Buoys. Various Signals

Radio Ship Control. R. S. Griffin. Mech. Eng. Jan. '22.
Telescopic Conveyor Halves Time of Handling Ship Cargoes.* G. F. Nicholson. Eng. N. R. Jan. 26, '22.
Tug with Grain Ship Discharging Plant.* Engr. Jan. 27, '22.
Cargo Steamer "Brynymor" for the Polecrest Steamship Co., Ltd.* Eng. Jan. 27, '22.
Le Pilotage par Cable Electrique Systeme Loth, des Navires et des Aéronefs.* (Directing Ships and Aircraft by an Electric Cable, Loth System.) P. Letheule. Gen. Civ. Dec. 10, '21.

d. Roads and Outer Harbors. Dike and Jetties. Breakwaters

The Proposed Harbour of Refuge at St. Ives, Cornwall.* F. C. Uren. Dock and Harbour Feb., '22.

Ueber die zweckmässigste Anordnung der äusseren Hafendamme von Seehäfen an sandiger Küste.* (The Most Suitable Arrangement of Outside Breakwaters for Maritime Harbors on Sandy Coasts.) Heiser. Zeit. Bau. Pt. 10, '20.

h. Wharves. Mooring Buoys. Harbor Equipment

Rangoon: The Town, the River and the Port, and the New Dock Scheme at Dawbon.* Dock and Harbor Jan., '22.

The Maintenance of Tidal Berths.* Ernest Latham. Engr. Jan. 27, '22.

Quelques Remarques à Propos des Conséquences de l' Accroissement des Navires sur les Dispositions des Ports. (Some Remarks Concerning the Consequences of the Enlargement of Ships upon Port Arrangements.) M. Renard. Ann. P. et C. Sept.–Oct., '21.

i. Harbors (General Articles)

Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators.* R. E. Knight. (Paper read before Inst. Mech. Engrs.) Engr. Dec. 23, '21.

The Commercial Development of the Port of Rotterdam.* D. Boomsma. Dock & H. Auth. serial beginning Jan., '22.

Port Authority Presents Arguments Against Narrows Tunnel. Eng. N. R. Feb. 16, '22.

L'Installation pour le Dechargement et la Manutention des Grains, à Bordeaux-Bassens.* (The Installation for Unloading and Handling Grain, at Bordeaux-Bassens.) Gen. Civ. Dec. 17, '21.

j. Dockyard Machinery and Shipyards

The Machinery of Floating Docks.* E. H. Salmon. Dock & H. Auth. Serial beginning Jan., '22.

Lake Coal Dock with Unloading and Handling Plant.* Eng. N. R. Jan. 19, '22.

Extensive Surface Repairs to a Concrete Dry Dock.* Eng. N. R. Jan. 19, '22.

H. Railroads, Street and Interurban Railways, Automobiles, Aeronautics

a. Railroads

1. General Articles

Development of Canadian Railway Construction. H. K. Wicksteed. (Paper read before Am. Assoc. for the Advancement of Science.) Can. Engr. Jan. 3, '22.

The Chilean Railroad Problem and Its Solution.* David C. Hershberger. Ry. Age Jan. 21, '22.

Le Nouveau Régime des Chemins de Fer de la Grande-Bretagne. Le "Railways Act, 1921".* (The New Management of the Railways of Great Britain.) Marcel Peschaud.. Rev. Gen. Jan., '22.

2. Location

Relocation on the South African Government Railways.* Eng. N. R. Jan. 19, '22.

Costly Railroad Re-location.* Cem. Eng. Feb., '22.

Die Umgestaltung der Leipziger Bahnanlagen durch die Preussische und die Sachsische Staatseisenbahnverwaltung.* (The Reconstruction of the Leipzig Railway Lay-out by the Prussian and Saxon State Railway Administration.) Rothe and others. Zeit. Bau. Serial beginning Pt. 4, '21.

3. Roadbed. Construction Work. Tunnels

On the Question of the Construction of the Road Bed and of the Track.* Henry and Candelier. Int. Ry. Assoc. Jan., '22.

Nickel Plate is Completing Grade Separation Work.* Ry. Age Jan. 14, '22.

Methods of Lining St. Paul Pass Tunnel of C., M. & St. P. Ry. C. F. Urbutt and S. H. George. (Abstract of paper read before Am. Ry. Bridge and Building Assoc.) Eng. Contr. Jan. 18, '22.

Research Settles the Problem of Tunnel Ventilation.* Robert G. Skerrett. Sci. Am. Mar., '22.

4. Track

On the Question of Special Steels.* Mesnager. Int. Ry. Assoc. Dec., '21.

Timber Treatment Promotes Economy in Maintenance of Way.* Ry. Main. Engr. Feb., '22.

Tie Production is now Twenty-five Per Cent. of Normal. Ry. Main. Engr. Feb., '22.

Getting the Maximum Performance Out of Locomotive Cranes.* Ry. Main. Engr. Feb., '22.

Welding Frogs and Crossings with Manganese Steel.* H. R. Pennington. (From paper read before Am. Welding Soc.) Ry. Rev. Feb. 4, '22.

Machines à Saboter, à Percer, à Tronçonner et à Marquer les Traverses de Chemins de Fer, Systeme Greenlee.* (Machines for Dressing, Boring, Trimming and Marking Railroad Ties, Greenlee System.) A. Pallet. Gen. Civ. Dec. 31, '21.

5. Signals and Safety Apparatus

The Train Control System of the "Midland Railway". L. D'Haenens. Int. Ry. Assoc. Dec., '21.

Cab Signalling and Automatic Train Stops.* J. Netter. (From *La Technique Moderne.*) Int. Ry. Assoc. Dec., '21.

I. C. C. Proposes to Order Automatic Train Control. Ry. Age Jan. 14, '22.

"M-V All Weather" Train Control on Raritan River.* Ry. Age Jan. 14, '22.

The Webb Automatic Train Stop Tested on the Erie.* Ry. Age Jan. 14, '22.

Block-Signal and Dispatching Systems in Metal Mines.* R. T. Murrill. Min. and Metal. Feb., '22.

Note sur le Moteur Electrique de Signal de la Compagnie de l'Est.* (Note upon the Electric Signalling Motor of the Compagnie de l'Est.) M. Picard. Rev. Gen. Dec., '21.

La Répétition des Signaux et l'Arrêt Automatique des Trains sur les Chemins de Fer Américains. (Repetition of Signals and Automatic Stopping of Trains on American Railroads.) M. de Boysson. Rev. Gen. Jan., '22.

5. Signals and Safety Apparatus—(*Continued*)

Note sur l'Application du Frein Continu aux Trains de Marchandises.* (Note on the Application of Continuous Brakes to Freight Trains.) Luigi Greppi. Rev. Gen. Jan., '22.

6. Rolling Stock (Locomotives, Cars)

On the Question of Bogies (Trucks), Axles and Springs of Locomotives.* E. Minsart. Int. Ry. Assoc. Dec., '21.

Transcontinental Comfort in New Steel Car Trains.* Ry. Rev. Dec. 31, '21.

New Sleeping Cars for the Canadian Pacific.* Ry. Rev. Dec. 31, '21.

Container Cars Curtail Waste in Railway Operation.* Walter C. Sanders. Ry. Rev. Dec. 31, '21.

On the Question of Bogies (Trucks), Axles, and Springs of Locomotives.* Mr. Bochet. Int. Ry. Assoc. Jan., '22.

Recent Tendencies in Locomotive Development.* R. C. Augur. Ry. Age Jan. 7, '22.

Essentials of Progressive Motive Power Policy. G. M. Basford. (Paper read before Central Ry. Club.) Ry. Age Jan. 14, '22.

Community Hospitals for Disabled Foreign Freight Cars.* J. J. Tatum. Ry. Rev. Jan. 21, '22.

New Sleeping and Compartment Cars for the C. P. R.* Ry. Rev. Jan. 21, '22.

A Practical and Powerful Gasoline Switch Locomotive.* L. C. Josephs, Jr. Ry. Rev. Jan. 21, '22.

Articulated Units Feature Recent English Car Design.* Ry. Rev. Jan. 28, '22.

The Teloc Locomotive Speed Indicator and Recorder.* Eng. Feb. 3, '22.

Three-Cylinder Locomotive for Spanish Railways.* Engr. Feb. 3, '22.

New Haven Using Motor Cars on Branch Lines.* Ry. Age Feb. 4, '22.

American Locomotives for the Manila Railroad.* Ry. Age Feb. 11, '22.

Appareils de Déchargement Mécanique des Wagons—Tomberaux Allemands.* (Apparatus for the Mechanical Unloading of German Dump-Cars.) M. H. Gaubert. Rev. Gen. Dec., '21.

Etude de l'Action des Charges Roulantes sur les Rails. (Study of the Action of Rolling Loads on Rails.) S. Timochenko. Gen. Civ. Dec. 24, '21.

Le Freinage Continu des Longs Trains de Marchandises.* (Continuous Braking of Long Freight Trains.) J. Netter. Gen. Civ. Serial beginning Dec. 24, '21.

Transformations Effectuées sur d'Anciennes Locomotives de la Compagnie des Chemins de Fer Andalous.* (Changes Effected upon the Old Locomotives of the Compagnie des Chemins de Fer Andalous.) M. Rennes. Rev. Gen. Jan., '22.

Uber Speisewasser-Vorwärmer für Lokomotiven. (On Feed Water Preheaters for Locomotives.) Oest. Ing. Arch. Ver. Dec. 2, '21.

Kugel und Rollenlager für Schienenfahrzeuge.* (Ball and Roller Bearings for Vehicles Running on Tracks.) H. Behr. Ver. deu. Ing. Dec. 3, '21.

Druckluftlokomotiven.* (Compressed Air Locomotives.) Schulte. Ver. deu. Ing. Dec. 24, '21.

7. Use of Electricity

On the Question of Electric Traction.* Alfredo Donati. Int. Ry. Assoc. Dec., '21.

On the Question of Electric Traction.* George Gibbs. Int. Ry. Assoc. Dec., '21.

An Electric Railway Within the Arctic Circle.* Engr. Dec. 23, '21.

Railway Electrification.* Vincent L. Raven. Engr. Serial beginning Dec. 23, '21.

On the Question of Electric Traction. Sabouret. Int. Ry. Assoc. Jan., '22.

The Electrification of the St. Gothard Railway.* Engr. Jan. 20, '22.

Electrification of Railways at Large Industrial Plants. D. M. Petty. (Abstract of paper read before the Assoc. of Iron and Steel Elec. Engrs.) Eng. N. R. Jan. 26, '22.

The Foremost French Railway Electrification Project.* G. de la Rochette. Ry. Rev. Feb. 4, '22.

Electric Traction for Steam Railroads. Ry. Age Feb. 4, '22.

Zur Wahl der Fahrspannung auf den französischen Hauptbahnen mit Gleichstrom-Betrieb. (Choice of Potential with Direct Current Operation on the French Main Railroads.) W. Kummer. Schw. Bauz. Dec. 17, '21.

8. Stations. Engine Houses. Shops. Terminals

On the Question of Goods (Freight) Stations.* Jullien and Montier. Int. Ry. Assoc. Jan., '22.

On the Question of Goods (Freight) Stations.* Edilio Ehrenfreund. Int. Ry. Assoc. Jan., '22.

Repair Shop and Engine-house Developments.* E. L. Woodward. Ry. Age Jan. 7, '22.

Handling Freight in the Country's Largest Terminal.* Ry. Age Jan. 21, '22.

Erie Railroad Adopts New Plan of Handling Freight at Manhattan Terminals.* Ry. Rev. Jan. 21, '22; Ry. Age Jan. 21, '22.

Revised Station Plans Embody New Features.* Ry. Age Feb. 4, '22.

Harrison Street Freight Terminal of the Chicago & Alton R. R. in Chicago.* Ry. Rev. Feb. 11, '22.

Entwurf für ein Empfangsgebäude auf Bahnhof Mülhausen im Elsass.* (Design for a Station Building at Mülhausen, Alsace.) Borchers. Z. d. Bauver. Apr. 2, '21.

Das Neue Geschäftsgebäude der Eisenbahndirektions Danzig.* (The New Offices of the Danzig Railway Administration.) Eitner. Z. d. Bauver. Jan. 4, '22.

9. Technical and Commercial Use.

Five Years of Freight Traffic Growth is Lost.* Harold F. Lane. Ry. Age Jan. 7, '22.

Cutting Freight Loss and Damage in Half.* K. H. Koach. Ry. Age Jan. 7, '22.

Railroads Profit from Lower Material Costs.* W. S. Lacher and C. B. Peck. Ry. Age Jan. 7, '22.

The Federal Valuation is Entering New Stages. E. T. Howson. Ry. Age Jan. 7, '22.

x. Miscellaneous

Improved Service and Morale Features of 1921. Charles W. Foss. Ry. Age Jan. 7, '22.

b. Special Railroads

1. Rack Railroads

Adhesion and Rack Locomotive for Sumatra.* S. Abt. Ry. Age Jan. 28, '22.

3. Narrow Gauge. Light Railways

On the Question of Carriages and Wagons for Light Railways. Carlo Gaviraghi. Int. Ry. Assoc. Dec., '21.

Peacetime Development of Light or Combat Railways.* Marshall R. Pugh. Mil. Engr. Jan.–Feb., '22.

Development of Light Railways in Great Britain. Eng. N. R. Feb. 2, '22.

Eisenbahnbauten für den Frontbetrieb.* (Railroad Building for the Battlefront). Kümmell. Zeit. Bau. Pt. 7, '20.

c. Ferry Boats

Ferry Cradle at St. Louis Embodies New Features.* F. E. Bates. Ry. Age Dec. 31, '21.

d. Street Railways, Elevated Railways, Subways

2. Location

Fortschritte in der Profilgestaltung der Untergrundbahnen und Statistische Untersuchung der rechteckigen Profilformen.* (Advances in Subway Cross-section and Static Investigation of the Rectangular Profile Shape.) E. M. Kilgus. Zeit. Bau. Pt. 1, '21.

4. Track

Experiences at Indianapolis in Welding Track Joints. T. H. David. (Abstract of paper read before Central Elec. Ry. Assoc.) Eng. Contr. Feb. 15, '22.

e. Automobiles

2. Internal Combustion Engine Automobiles

An Omnibus Overhauling Depot.* Engr. Feb. 3, '22.

x. Miscellaneous

Strassenhygiene und Automobilauspuff. (Street Hygiene and Automobile Exhaust.) Georg Wolff. Gesund. Ing. June 4, '21.

f. Aeronautics

2. Dirigible Balloons

Projet de Dirigeable, Système Vaugean-Gargiulo, à Raréfaction Variable. Moteur fixe à deux Temps et à Huile Lourde.* (Design of an Airship, Vaugean-Gargiulo System, with Variable Rarefaction. Heavy-Oil Two-Cycle Stationary Engine.) E. Garuffa. Gen. Civ. Dec. 17, '21.

3. Aeroplanes

Commercial Operation of Airplanes.* L. B. Lent. Mech. Eng. Jan., '22.

L'Avion "Empress Vimy" pour les Transports en Commun Aériens.* (The Aeroplane "Empress Vimy" for Ordinary Aerial Transportation.) Gen. Civ. Dec. 24, '21.

Grossflugzeuge der Zeppelinwerke Staaken.* (Large Airplanes of the Staaken Zeppelin Works.) E. Meyer. Schw. Bauz. Serial beginning Dec. 10, '21.

x. Miscellaneous

Phare Electrique très Puissant pour la Navigation Aérienne.* (A Very Powerful Electric Lighthouse for Aerial Navigation.) Ch. Dantin. Gen. Civ. Dec. 24, '21.

I. Municipal Water-Works. Agricultural Engineering

a. General Articles

General Requirements of the National Board of Fire Underwriters in Regard to Water Works. Robt. E. Andrews. Am. W. W. Assoc. Jan., '22.

The Erie Water Works Plant.* J. N. Chester and J. S. Dunwoody. Am. W. W. Assoc. Jan., '22.

Construction Scarboro Twp. Waterworks System.* W. D. Proctor. Can. Engr. Jan. 10, '22.

Die Erschliessung neuer Landgebiete in den Amerikanischen Weststaaten durch Bewässerung.* (Opening up New Agricultural Regions in the American Western States by Irrigation.) Bruno Simmersbach. Zeit. Bau. Pt. 4, '21.

b. Hydrology. Water Resources

State Control of Water Supplies. (From Committee report read before Boston conference of State Sanitary Engrs.) Eng. Contr. Jan. 11, '22.

Underground *vs.* Surface Water Supplies, with Special Reference to Wauseon, Ohio.* W. J. Sherman. Mun. & Co. Eng. Feb., '22.

Methods of Blasting Drilled Wells to Increase Flow of Water.* S. R. Russell. (From *The Du Pont Magazine.*) Eng. Contr. Feb. 8, '22.

c. Dams and Reservoirs

Alternate Plans for Proposed Colorado River Dam. Arthur P. Davis. Eng. N. R. Feb. 2, '22.

Construction Features of Hartebeestpoort Dam of South African Irrigation Department.* Eng. Contr. Feb. 8, '22.

Näherungsformel zur Bestimmung des Staubeckeninhaltes.* (Approximate formula for determining the Contents of Storage Basins.) Alexander Grossauer. Oest. Ing. Arch. Ver. Jan. 6, '22.

d. Analysis and Purification of Water

Hydrogen-ion Concentration and Water Supply Problems. Frank Hannan. Am. W. W. Assoc. Jan., 22.

Certain Obscure Relations of Drinking Water to Disease. H. E. Robertson. Am. W. W. Assoc. Jan., '22.

d. Analysis and Purification of Water—(*Continued*)

Shortcomings in the Present Standard Methods of Water Analysis from the Operator's Viewpoint. Lewis I. Birdsall. Am. W. W. Assoc. Jan., '22.
The Reactions of Culture Media.* George C. Bunker and Henry Schuber. Am. W. W. Assoc. Jan., '22.
Synura and Other Organisms in Catskill Water Supply.* W. W. Brush. Eng. N. R. Feb. 16, '22.

e. Distribution of Water

Cast Iron Water Service Pipe.* Mun. and Co. Eng. Jan., '22.
Ownership and Operation of Trench Excavators and Other Mechanical Equipment by the Water Department of Baltimore.* V. Bernard Siems. Am. W. W. Assoc. Jan., '22.
Tapping Large Steel Mains Under Pressure. D. F. O'Brien. Am. W. W. Assoc. Jan., '22.
Terre Haute Water Company Uses Malleable Street Vault Covers to Stand Shocks of Heavy Truck Wheels.* Dow R. Gwinn. Mun. and Co. Eng. Feb., '22.
Electric Control and Operation of Water Valves at Buffalo.* George C. Andrews. Eng. N. R. Feb. 2, '22.
Special Cast-Iron Pipe Used for Whittier Water-Works.* E. A. Rowe. Eng. N. R. Feb. 2, '22.
Proper Charges for Fire Protection (Water Supply). Henry L. Gray. Eng. Contr. Feb. 8, '22.
Design and Construction of Welded Steel and Wood-Stave Pipe Line for Butte Water Co.* Eugene Carroll. Eng. N. R. Feb. 16, '22.
Le Diamétre le plus Economique d'Uune Conduite Forcée.* (The Most Economical Diameter for a Pressure Pipe.) Aldo Lombardi. Gen. Civ. Dec. 31, '21.
Der Ausbau der vorhandenen Zuleitung für die Wasserversorgung von München aus dem Mangfalltal und die Wasserkraftnutzung bei Wasserversorgungsanlagen.* (The Construction of the Present Pipe Line for the Münich Water Supply from the Mangfall Valley and the Utilization of the Water Power by the Water Works.) A. Neuber. Gesund. Ing. June 18, '21.

f. Drainage of Land

The Conservancy of Marsh Lands.* Ernest Latham. Eng. Jan. 6, '22.
Pumping Plants for Drainage Systems. L. C. Craig. (Paper read before National Drainage Congress.) Eng. Contr. Jan. 11, '22.

J. Sewerage. Sewage and Refuse Disposal

a. Sewers and Drains

Manchester's New Outfall Sewer.* Engr. Jan. 13, '22.

b. Sewage Disposal. Purification

Power from Sewage Gas.* Engr. Serial beginning Dec. 16, '21.
Some Notes on Colloidal Chemistry. Milton F. Stein. Can. Engr. Dec. 29, '21.
The Maintenance of Clean Filtering Medium in Sewage Filters. Herbert D. Bell. (Abstract of paper read before Yorkshire District, Assoc. of Mgrs. of Sewage Disposal Works.) Can. Engr. Jan. 17, '22.
The New Orleans Automatic Sewage Pumping Stations.* George G. Earl. Eng. N. R. Jan. 19, '22.
The Operation of Sewage Treatment Plants. John H. Dunlap. Can. Engr. Jan. 24, '22.
Sewage: The Price of Civilization.* Harry A. Mount. Sci. Am. Feb., '22.
Compact Sewage-Works for Annexed District of Rochester.* John F. Skinner. Eng. N. R. Feb. 2, '22.
Results of Fine Screening and Sludge Dewatering Experiments at Milwaukee. (From annual report of Sewerage Commission of Milwaukee.) Eng. Contr. Feb. 8, '22.
Comparative Methods of Lifting Sewage. F. G. Lloyd. Can. Engr. Feb. 14, '22.
Le Traitement des Ordures Ménagères. Nouvelles Dispositions Adoptées par la Ville de Paris.* (Treatment of Household Garbage. New Arrangements Adopted by the City of Paris.) Paul Razous. Gen. Civ. Serial beginning Jan. 7, '22.
Auszug aus dem Gutachten zur Abwasserfrage in der Stadt Schramberg im Schwarzwald. (Extracts from Expert Opinions on the Waste Water Question in the City of Schramberg in Schwarzwald.) Th. Heyd. Gesund. Ing. June 18, '21.
Giftwirkungen und Schädigungen durch Abwasser. (Poisonous and Injurious Effects Due to Waste Water.) O. Kammann. Gesund. Ing. Serial beginning June 18, '21.
Die Kläranlagen Hamburgs und seiner Nachbarstädte. (The Clarifying Plants at Hamburg and Its Neighboring Cities.) P. Keim. Gesund. Ing. June 18, '21.
Uber die Beseitigung neuartiger Abwasser aus der Kriegswirtschaft. (On the Removal of New Kinds of Waste Water Resulting from the War Industries.) O. Kammann. Gesund. Ing. June 18, '21.

c. Refuse Disposal

Chicago's Garbage Problem.* Lawrence F. King. West. Soc. Engrs. Feb., '22.
Present Day Aspects of the Refuse Disposal Problem.* Samuel A. Greeley. West. Soc. Engrs. Feb., '22.
Refuse Disposal in Smaller Cities and Towns. Rolland S. Wallis. (Abstract of paper read before Iowa Eng. Soc.) Eng. Contr. Feb. 8, '22.

K. Heat Engines

a. Steam Engines. Boilers

Power Generation in Steel Plants.* D. M. Petty. Eng. Club, Phil., Dec., '21.
The Proportioning of Steam Turbine Blading.* Harold Medway Martin. Eng. Serial beginning Jan. 6, '22.

a. Steam Engines. Boilers—(*Continued*)

The Steam-Engine Indicator.* Power Jan. 24, '22.
A Near Boiler Explosion.* G. W. Atkinson. Power Feb. 7, '22.
Erfahrungen im Betrieb grosser Dampfturbinen.* (Experiences in Operating Large Steam Turbines.) Duffing. Ver. deu. Ing. Dec. 10, '21.

b. Gas and Oil Engines

Compounding the Combustion Engine.* Elmer A. Sperry. Mech. Eng., Jan., '22.
Die Darstellung des Arbeitsvorganges der Brennkraftmaschinen.* (Presentation of the Working Processes of the Combustion Engine.) P. Meyer. Ver. deu. Ing. Nov. 26, '21.

L. Electricity

a. Production of Electricity

1. Storage Batteries and Cells.
Heat Losses in Stranded Armature Conductors.* Waldo V. Lyon. A. I. E. E. Jan., '22.
The Petersen Earth Coil.* R. N. Conwell and R. D. Evans. A. I. E. E. Feb., '22.
2. Magneto and Dynamo. Electric Machines
Polyphase Commutator Machines.* A. B. Field. A. I. E. E. Jan., '22.
Current Locus of Single-Phase Induction Motors. J. K. Kostko. A. I. E. E. Jan., '22.
Prevention of Transient Voltage in Windings.* J. Murray Weed. A. I. E. E. Jan., '22.
The "Indumor", a Kinematic Device Which Indicates the Performance of a Polyphase Induction Machine.* Vladimir Karapetoff. A. I. E. E. Feb., '22.

b. Distribution and Transmission of Electricity
1. Power Plants
Heat Balance of the Connors Creek Plant of the Detroit Edison Company.* C. Harold Berry and F. E. Moreton. Mech. Eng. Jan., '22.
2. Long-Distance Transmission of Energy
Wave Form and Amplification of Corona Discharge.* J. B. Whitehead and N. Inouye. A. I. E. E. Jan., '22.
3. Distribution and Wiring of Electricity
Die Berechnung der Kapazität elektrischer Leitungen und damit zusammenhängende Aufgaben.* (The Calculation of the Capacity of Electric Networks and Problems Connected Therewith.) Richard Hieche. Oest. Ing. Arch. Ver. Dec. 9, '21.
Questions on the Economic Value of the Overhead Grounded Wire.* E. E. F. Creighton. A. I. E. E. Jan., '22.
Recommendations on Conduit Placed in Cinder Concrete. (From *Journal* of the Am. Soc. of Architects). Eng. Contr. Jan. 25, '22.
Energy Front of Electric Circuits.* Charles P. Steinmetz. A. I. E. E. Feb., '22.
5. Transformers and Converters
Care and Operation of Power Transformers. J. G. Corrin. Eng. Club, Phil., Dec., '22.
6. Safety of Electric Distribution Systems. Laws and Regulations
On Deviations from Standard Practise in Lighting Arresters.* E. E. F. Creighton. A. I. E. E. Feb., '22.

c. Electric Lighting

1. Arc, Incandescent, Mercury Vapor, Neon Lamps, etc.
Emergency Safety Lamp.* Eng. Jan. 27, '22.

d. Mechanical Uses of Electricity

2. Servomotors, Hoists, Elevators, Handling Machinery
Electric Power Application to Passenger and Freight Elevators.* Harrison P. Reed. A. I. E. E. Serial beginning Jan., '22.

f. Signals and Communication

Printing Telegraph Systems Applied to Message Traffic Handling.* A. H. Reiber. A. I. E. E. Feb., '22.
Submarine Cable Telegraphy.* J. Willard Milnor. A. I. E. E. Feb., '22.
La Station Radiotélégraphique de New-Brunswick (New-Jersey, Etats-Unis.)* (The New Brunswick (New Jersey, U. S. A.) Radiotelegraph Station.) Jacques Lynn. Gen. Civ. Serial beginning Jan. 14, '22.

x. Miscellaneous

The Use of Superimposed Imaginary E. M. Fs. Currents, and Fluxes in the Solution of Alternating-Current Problems. Vladimir Karapetoff. A. I. E. E. Jan., '22.
The Effects of Moisture on the Thermal Conductivity of Soils With a Bibliography on the Heating of Cables.* G. B. Shanklin. A. I. E. E. Feb., '22.

M. Architecture

b. Business and Commercial Buildings

Liquefied Rubber Fire Wrecks Concrete Roof.* A. B. MacMillan. Eng. N. R. Jan. 26, '22.
Some Further Observations on the Rubber Company Fire. J. Wm. Moffett. Eng. N. R. Jan. 26, '22.

c. Residences. Hotels

The First Copartnership Housing Venture in the United States. Clarence S. Stein. (From the *Journal* of the Am. Inst. of Architects.) Eng. Contr. Jan. 25, '22.
Bristol Housing Scheme. Lessel S. McKenzie. Inst. Mun. & Co. Engrs. Jan. 14, '22.

d. Storage Buildings

Pneumatic Grain Elevator and Sack Handling Plant at the Port of Bordeaux. Dock & Harbor Jan., '22.

g. Other Buildings

Das Stadtbad Neukolln.* (Municipal Bath House at Neukoln.) Ernst Nagel. Gesund. Ing. May 14, '21.

h. Roof. Domes

Westminster Hall Roof and Mediæval Constructional Expedients.* William Harvey. Engr. Dec. 30, '21.

x. Miscellaneous

The Moving of Brick Buildings.* Eng. Dec. 23, '21.
Building Codes. R. Fleming. (From paper read before Engrs.' Club of Trenton, N. J.) Eng. Contr. Jan. 25, '22.

N. Landscape Engineering

Town Planning. G. L. Pepler. Inst. Mun. & Co. Engrs. Dec. 17, '21.
The Land Question as Related to City Planning and Housing. George Herbert Gray. (From *Journal* of Am. Soc. of Architects.) Eng. Contr. Dec. 28, '21.
A Brief Survey of City Planning Reports in the United States, 1921. Theodora Kimball. Land. Arch. Jan., '22.
Extension Work in Landscape Architecture. A Symposium. Land Arch. Jan., '22.
Transportation and Development of Modern Cities. Paul Seurot. (Paper read before Town Planning Convention.) Can. Engr. Jan. 10. '22.

O. Administration—Legislation—Economics—Statistics

b. Economic Question of a General Character; Valuations, etc.

Engineering Standardization. R. E. Durley. (Paper read before Am. Assoc. for the Advancement of Science.) Can. Engr. Jan. 10, '22.

c. Statistics of General Interest

Statistics of Construction Cost and Volume.* Eng. N. R. Jan. 5, '22.

d. Economic Role, Administrative and Financial Management of Means of Communications; Rates, Conditions and Statistics of Transportation.

5. Railroads and Street Railways

Report of the Swiss Federal Council to the Federal Assembly on the Report of the Federal Railways Commission of the National Council: the Financial Situation of the Federal Railways and Their Electrification Programme.* Int. Ry. Assoc. Jan., '22.
On the Question of the Net Cost. Samuel O. Dunn. Int. Ry. Assoc. Jan., '22.
An Analysis of the Railway Statistics for 1921.* Julius H. Parmelee. Ry. Age Jan. 7, '22.
Division Accounting—An Operating Viewpoint.* J. E. Slater. Ry. Age Serial beginning Feb. 4, '22.

e. Legislation—Questions Concerning Wages and Working Conditions

Elements of an Engineer's Employment Contract. John E. Hughes. (From *Professional Engineer.*) Eng. Contr. Jan. 18, '22.

f. Engineering Ethics

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INSTITUTED 1852.

PAPERS AND DISCUSSIONS

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Vol. XLVIII. MARCH, 1922. No. 3.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

THE CONTINUOUS TRUSS BRIDGE OVER THE OHIO RIVER AT SCIOTOVILLE, OHIO, OF THE CHESAPEAKE AND OHIO NORTHERN RAILWAY

By Gustav Lindenthal,* M. Am. Soc. C. E.

To be Presented April 5th, 1922.

Synopsis

The peculiar construction of the Sciotoville Bridge has been the subject of frequent inquiries, and the following detailed, although somewhat belated, description will serve as a permanent record, useful for similar bridge construction elsewhere.

The distinguishing features of the design are four: Continuous trusses over two long spans; floor-beams, acting as inverted arches and braced against tractive forces; erection with the minimum of falsework and without extra material in the trusses; and riveted connections to the limit of the largest rolling mill and shop facilities. The subject-matter is presented herewith under the following heads:

1.—General Conditions and Selection of Design.
2.—History and Characteristics of Continuous Truss Bridges.
3.—Substructure.
4.—Steel Superstructure.
5.—Fabrication and Erection of Steelwork.

1.—General Conditions and Selection of Design

Location and Grades.—When it was decided by the Chesapeake and Ohio Northern Railway Company to bridge the Ohio River and connect with the main line of the Chesapeake and Ohio Railway, on the Kentucky side (the

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

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southern or left bank) of the Ohio River, the crossing was selected so as to form a direct route from the junction to Columbus, Ohio, along the valleys of the Little Scioto and the Scioto Rivers, with exceptionally favorable grades for the heavy coal transportation to the Great Lakes *via* the Hocking Valley Railway. Going north, the grades are 0.2% and, going south, 0.3%, and are compensated on curves. The line has a single track for the present, but the Ohio River Bridge and the masonry piers of the approach viaducts are built for two tracks. With the coal traffic steadily growing, two tracks for the entire line will be necessary before long. The double-track bridge was built at a period of low prices, thus enhancing its economic advantage in the development and growth of that important traffic.

River Conditions.—At the site of the bridge, the Ohio River has a width of about 1 600 ft. between embankments and forms a sharp bend. The river channel is near the inner or Kentucky shore, but at high-water stages, the traffic shifts toward the Ohio shore, along which also, at times, considerable ice and drift are carried.

The river channel is 5 ft. deep at low water and 72 ft. deep at high water. The river bottom which is practically bare rock, with a slight slope from the Ohio toward the Kentucky shore, afforded a solid foundation for the piers.

The requirements of the War Department called for a minimum clear height under the bridge of 90 ft. above low water and 40 ft. above high water. The navigation interests demanded large openings, owing to the danger by obstructing piers to the descending coal tows some of which are 150 ft. wide and 700 ft. long and (at this sharp bend of the river, at the head of the shoals of the Little Scioto River) are difficult to control, particularly on account of the dense smoke and fog prevalent in this locality. On the Kentucky side it was also necessary to keep the river channel open for navigation during the erection of the bridge.

Selection of Design.—After several layouts with different span lengths, it appeared that with two spans of 750 ft. each in the clear and a pier in the middle of the river, the requirements of the navigation interests, and of the War Department would be satisfied. This made possible a symmetrical and sightly structure with two spans 775 ft., center to center, of bearings. (Fig. 1.)

The rock foundations were favorable to a continuous truss bridge, which also offered the advantage of erection with a minimum of falsework. Two simple truss spans of 775 ft. each, would have been from 15 to 20% more expensive for metal and erection.

The span of 775 ft. exceeds in length the longest existing simple span bridge, namely, the 720-ft. span of the Ohio River Bridge, at Metropolis, Ill., built in 1917.

It will thus be seen, that the selection of continuous trusses was primarily indicated in this case by reasons of economy in metal and by facilities of erection.

2.—History and Characteristics of Continuous Truss Bridges

In view of the fact that this bridge has the longest spans of the continuous truss type, and thus comes into competition, for long spans, particularly with

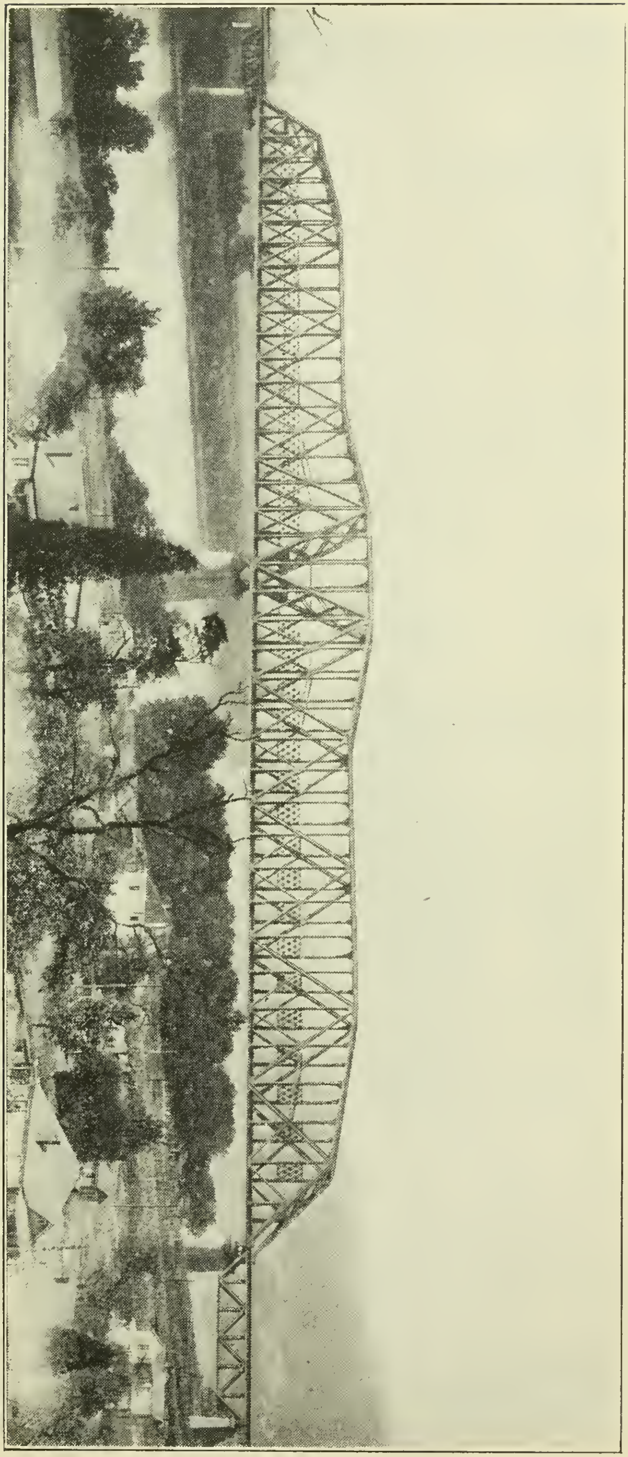


Fig. 1.—Sciotoville Bridge Over the Ohio River.

the simple span and the cantilever type, it appears appropriate to review briefly its history and some of its characteristics not generally appreciated by American bridge engineers.

History.—The Britannia Bridge in England, built by Stephenson in 1848, marks a milestone in bridge construction, not only because it was the first important iron bridge of the beam type, but also because it was the first representative of the continuous girder type. It is a tubular plate girder bridge of four spans, two of which are 230 ft. and two of 460 ft. The girders were proportioned as simple beams, but the designer, realizing that continuity increased the carrying capacity, regarded this feature as an additional safety. To gain more information, he made tests with a model, and thus found the points of contraflexure of the elastic line, which he regarded as "fixed" and as dividing the span into two "cantilevers" and a "central beam". This laid the foundation for the later development of the modern cantilever bridge by the introduction of hinges at the points of contraflexure.

Too much credit cannot be given to that galaxy of early English bridge engineers of nearly one hundred years ago—Stephenson, Fairbairn, Telford, Tierney Clark—for the originality and daring of their plans and constructions. They did their own thinking; they did not wait for precedents, but created them. Theirs was the genius that originates as distinguished from routine which merely imitates.

The Britannia Bridge was followed by several similar bridges, among which may be mentioned the Torksey Bridge, built in 1849, over the Trent, with two spans of 130 ft., and the Bryne Bridge, built in 1855, with a central span of 267 ft. and two side spans of 141 ft. each.

In the latter part of the Nineteenth Century continuous truss bridges were extensively built on the Continent, principally in France, and were usually of the lattice truss type with parallel chords, with from three to five spans. The Fades Viaduct over the Sioule River, in France, built from 1905 to 1908, with a central span of 472 ft., was the longest continuous span previous to the building of the Sciotoville Bridge.

The Lachine Bridge, built in 1888, by the late C. Shaler Smith, M. Am. Soc. C. E., over the St. Lawrence River, near Montreal, Que., Canada, with two side spans of 269 ft., and two middle spans of 408 ft., was, for 29 years, the only continuous bridge in America. It was built as a cantilever and then converted into a continuous truss for the live load. It was replaced in 1910 by a simple span bridge.

There has been always more or less prejudice against continuous trusses, because cantilever trusses offer the alleged more accurate computation of stresses on purely statical principles. No continuous girder as far as known has ever failed in the trusses, whereas the largest and most discreditable bridge failure belongs to the supposedly accurate cantilever type.

It appears now, however, as if the continuous truss would again come into its own, for not only was it adopted for the Sciotoville Bridge, but also for the bridge of the Bessemer and Lake Erie Railroad built in 1918 over the Allegheny River near Pittsburgh, Pa., with spans of from 272 ft. to 520 ft., and

for the bridge of the Hudson Bay Railway, across the Nelson River, built in 1918, with spans of 300 ft. and 400 ft.

Characteristics of Continuous Bridges.—The continuous truss type has nowhere met with more indiscriminate and unqualified condemnation than by engineers in the United States, who have alleged three principal objections against it, none of which is novel or decisive:

1st.—That it is statically indeterminate, that is, its reactions and stresses are dependent on the elasticity of its members;

2d.—That it is subject to stresses from unequal settlements of its supports; and,

3d.—That it is affected by temperature changes.

Although these characteristics may be objectionable in certain cases, it can be readily shown that they are entirely unobjectionable in others, and they will be briefly discussed.

Static Indeterminateness

The argument that the stress computations are complicated can be readily dismissed. For preliminary and comparative designs, the simplifying assumption of constant moment of inertia of the vertical section through the girder or truss and the neglect of the elastic deformation of the web members, furnish sufficiently accurate and quick results. For the final design, the slight additional time and labor involved in the accurate calculation is of no account since continuous bridges will never be a common type.

The stress calculation, of course, is the more complicated the greater the number of spans, but, for other reasons, it is not advisable to have more than three or four spans in a continuous bridge.

The fact that the stresses are, to a certain extent, dependent on the elastic deformation of the members, is characteristic of all statically indeterminate structures, but in a properly designed continuous bridge the effect of even large variations in the elastic behavior is insignificant when compared with other uncertain stresses, such as secondary stresses, etc., which exist also in statically determinate structures.

Variation between the actual and the calculated elastic deformation may be due, first, to a difference between the assumed and the actual modulus of elasticity; and, second, to the influence of the details, such as gussets, splice and tie-plates, rivets, etc., which can only be roughly estimated.

A proportional change in the modulus of elasticity or in the sectional area of all members due to allowance for details has no influence on the reactions and stresses, but only on the deflections which change in the same proportion with the moduli.

The effect of non-proportional changes is well illustrated by a comparison of two sets of calculations made for the Sciotoville Bridge. It was planned that, during the various stages of erection, the trusses would pass successively through static conditions of a beam on two, three, four, and five supports (see Plate VI). The calculation of the reactions, for the purpose of determining the necessary jacking forces at the temporary supports, and of the deflections,

for determining the jacking heights, were made, first, on the basis of the gross area of the main section of the members without allowance for details and, second, on the basis of gross area of the main section plus the area of a section equivalent to 75% of the weight of the details. This additional area, due to details, varies for different members from 5 to 25% and averages about 20% of the gross area of the main section. For these two extreme assumptions, certain deflections differ by 25 to 60%, whereas the reactions differ by not more than 0.2% in the two-span condition, 465 ft.-775 ft., 10% in the three-span condition, 155 ft.-465 ft.-775 ft., 60% in the four-span condition, 155 ft.-155 ft.-465 ft.-775 ft., 11% in the three-span condition, 310 ft.-465 ft.-775 ft., and 0.7% in the final two-span condition, 775 ft.-775 ft.

The large differences in the reactions in the three and four-span conditions are due principally to the great variation in the length of the spans and to the comparatively great height of the short spans. Continuous trusses of great height and greatly different span lengths are, therefore, rightly objectionable, the more so, because they are also sensitive to settlements of the supports and to temperature changes. During erection, such a condition is of no consequence, because the reactions can be measured and the bearings promptly adjusted in height if necessary. Where the spans are more nearly equal, and the trusses not unusually high in comparison with the span length, the effect on the reactions and stresses from a variation in the elasticity of the trusses is practically insignificant.

As a precaution, and to obviate any uncertainty of stress action, from dead load at least, it is always possible and advisable, as was done in the case of the Sciotoville Bridge, to measure certain reactions, and, if necessary, to adjust the height of the bearings until the reactions are correct.

In no case should the variation in span length in a continuous truss be so great that the live load on any span will cause a reversal of the dead load reactions of the adjoining span. For all these reasons, continuous trusses over several spans and on metallic towers, or on steel arches, should preferably be shallow in depth, a rule first practiced by French engineers.

It is interesting to note that the actual deflections of the Sciotoville trusses, as observed in the field, were nearly midway between the values computed under the two previously mentioned assumptions; in other words, an average addition of about 10% to the gross areas of the sections, to allow for details, should be made when calculating elastic deformations.

Effect of Settlements or Compressibility of Supports

Where considerable settlements of the foundations are to be anticipated, or where the supports are high elastic towers, the continuous type of bridge is not advisable, unless care is taken to eliminate the effect of inconstant levels by means of adjustable bearings.

The stresses caused by the ordinary compressibility of the supports can be computed and, if they are not unduly large, can be neglected or provision can be made in the sections.

Settlements of the foundations are less objectionable the longer the spans, as already mentioned. For similar continuous trusses with equal proportion of height to span length, the same settlement of a support causes stresses approximately in inverse proportion to the span length. Since settlements may be assumed as proportional to the foundation pressure and since the latter is about the same for long and short spans, under the same soil conditions, it follows that, in general, the danger of excessive stresses due to settlements is less the greater the span lengths. In special eases, it may be advisable to design the permanent details of the truss bearings on the piers and abutments so that they may be raised or lowered by hydraulic jacks at any time, as needed to maintain the original levels.

In the case of the Sciotoville Bridge, a settlement of 2 in. in one of the end piers, if it was possible, or a settlement of 1 in. in the middle pier, the others remaining undisturbed, would change the reactions by only 0.6 per cent. It is evident that even a considerably greater settlement, which would seriously disturb the vertical alignment of the track, would not objectionably affect the stress condition in the trusses. When the Kentucky end of the bridge was raised to its final position, after erection had been completed, difference in the jacking force for the last 3 in. of jacking was noticeable. This shows that for spans of this length continuous trusses are unobjectionable, even if the foundations do not rest on solid rock.

As already mentioned, the first continuous trusses had solid webs (Britannia Tunnel Bridge) and on the Continent small mesh lattice webs. The secondary stresses in the web are of no importance in the first type and, in the latter type, they may be considered rather beneficial, since they contribute to stiffness and absorb some of the bending stresses on the trusses, proven by the fact that the lattice can bear some load when the chords are cut away, only the ehord sections over the bearings may need reinforcement against bending. In some instances, the continuous small mesh web girders over several spans were erected on falsework with a camber of $\frac{1}{500}$ to $\frac{1}{300}$ of the entire length of bridge and then let down on the pier bearings, to produce in the trusses initial bending stresses opposite those from live load. Such was the procedure of erection of the continuous truss viaduct of five spans on high iron towers over the Thur at Ossingen, Switzerland, in 1873. The writer was on the Engineering Staff for that structure, for which the statical computations were considered quite a feat at that time.

Temperature Effects

Temperature stresses in continuous trusses may be caused, first, by the expansion or contraction of intermediate supports, particularly high steel towers, and, second, by unequal temperature changes in different parts of the trusses themselves (uniform temperature changes in all members cause no stresses).

The first effect is similar to that of settlement of the piers and is greater, the higher the intermediate supports and the shorter the spans. In some existing bridges, it amounts to as much as 25% of the stresses from dead

and live load. It is, however, insignificant and negligible in the case of long spans resting on shallow piers. As the stresses can be calculated, it is easy to make the necessary provision in the sections.

The second effect is neglected, as a rule, although in a case where the bottom chords are protected from the direct rays of the sun by a solid floor, the temperatures in the top and bottom chords may differ considerably. The effect of such a difference is similar to that of a variation in the elasticity of the truss members and may be serious in a case where the lengths of spans vary considerably.

In the case of the Sciotoville Bridge an average difference in temperature of 10° Fahr., between the top and bottom chord (the effect of the web members is insignificant), would change the end reactions by only 1.5%, which is negligible.

Summing up, one arrives at the well established conclusion that continuous trusses are generally unobjectionable under the following conditions:

1st.—Where the lengths of the spans do not vary greatly, and the trusses are not unusually high as compared with the span length.

2d.—Where the foundations rest on fairly solid ground, compressibility of the soil being less objectionable the longer the spans.

3d.—Where the intermediate supports are not excessively high in comparison with the span length.

In every continuous truss there are a few members, such as the chords near the points of contraflexure, or web members near points of maximum moment, which are most sensitive to the effects enumerated, because their sections, as required by the dead and live load stresses, are comparatively small. Such members, as a rule, will require for fabrication or erection purposes a section somewhat in excess of that required by the stresses, to provide a certain margin for possible variation. It is advisable always to investigate such members and proportion them so that they are strong enough under reasonably extreme assumptions.

Advantages of Continuous Trusses.—Against the disadvantages mentioned, as far as they can be classed as such in any given case, must be weighed the advantages which the continuous type possesses over the simple span or the cantilever.

As regards economy, it is not feasible to make a general comparison between the continuous bridge and the cantilever since that depends largely on the arrangement of the spans, which is usually governed by local conditions and of necessity must be different for the two types, owing to their different character. In comparison with a series of simple spans of the same length, however, the continuous truss shows a decided economy which is greater the longer the spans and, up to a certain limit, greater the number of spans. For long spans, the saving in cost may be as much as 25 per cent. For short spans, the economy over simple spans is not important, but greater rigidity under passing loads is an advantage.

In point of rigidity, as measured by the deflections, the continuous truss compares favorably with the simple span and shows a decided advantage over

the cantilever. Its deflections and amplitude of vibrations are smaller, and the elastic line smoother and devoid of local kinks such as occur at the hinges of cantilevers. Both rigidity and economy gain from the fact that truss members subject to reversion of stress (tension and compression) can be riveted members proportioned only for the larger stress.

As is characteristic of all statically indeterminate structures, the continuous truss has the advantage in that when a member is seriously weakened, as may happen in the case of the derailment of a train and collision with the trusses, the probability of failure of the whole bridge is less than in the case of the statically determinate simple span or a cantilever. This greater safety is still more pronounced when the truss webs consist of small mesh lattice.

The continuous bridge presents no greater difficulties in erection than the cantilever, but it offers the advantage over the simple span in that it can be erected on the cantilever principle without, or with little, additional material. This was one of the governing factors in the case of the Sciotoville Bridge.

From the esthetic point of view the continuous bridge can well compete with the simple span or cantilever, if properly designed, but not with the more artistic arch or suspension bridge.

3.—Substructure

Foundations.—All the piers rest on solid shale rock which has nearly vertical stratification. The maximum foundation pressure is 9.5 tons per sq. ft. from vertical loads only and 12.5 tons per sq. ft., with longitudinal force acting.

The foundations presented no unusual problems, except that the center pier required a very heavy coffer-dam to obviate the danger of the coffer-dam being washed away by flood since it had to rest on bare rock bottom.

Piers.—The piers are of concrete, reinforced with steel rods to prevent shrinkage and temperature cracks. Both the up and down-stream ends of the piers are semicircular. The tops are marked by octagonally shaped massive copings which give a neat appearance at no additional expense.

The surfaces are plain, having been wetted and rubbed to a smooth finish with concrete bricks immediately after the forms were removed. The top surfaces were troweled to a smooth finish before the concrete had set and, after hardening, received two coats of cement filler.

The center pier which resists the longitudinal force from the entire bridge and carries a vertical load of 16 400 tons, is 18 by 63 ft. under the coping and has a batter all around of 1 : 10. The shore piers which carry only vertical loads of 5 100 tons, are 12 by 57 ft. under the coping and are battered 1 : 20.

The concrete is mixed in the proportion of 1 part Lehigh Portland cement, 2 parts sand, and 4 parts gravel. Sand and gravel of excellent quality were obtained from a river bank a few miles below the bridge site. The reinforcement consists of 1-in. square steel rods, arranged as shown on Fig. 2. The copings are reinforced longitudinally by 20-in. by 80-lb. beams, spaced 2 ft. apart and running the full length of the pier. They serve also to distribute the load from the bearings.

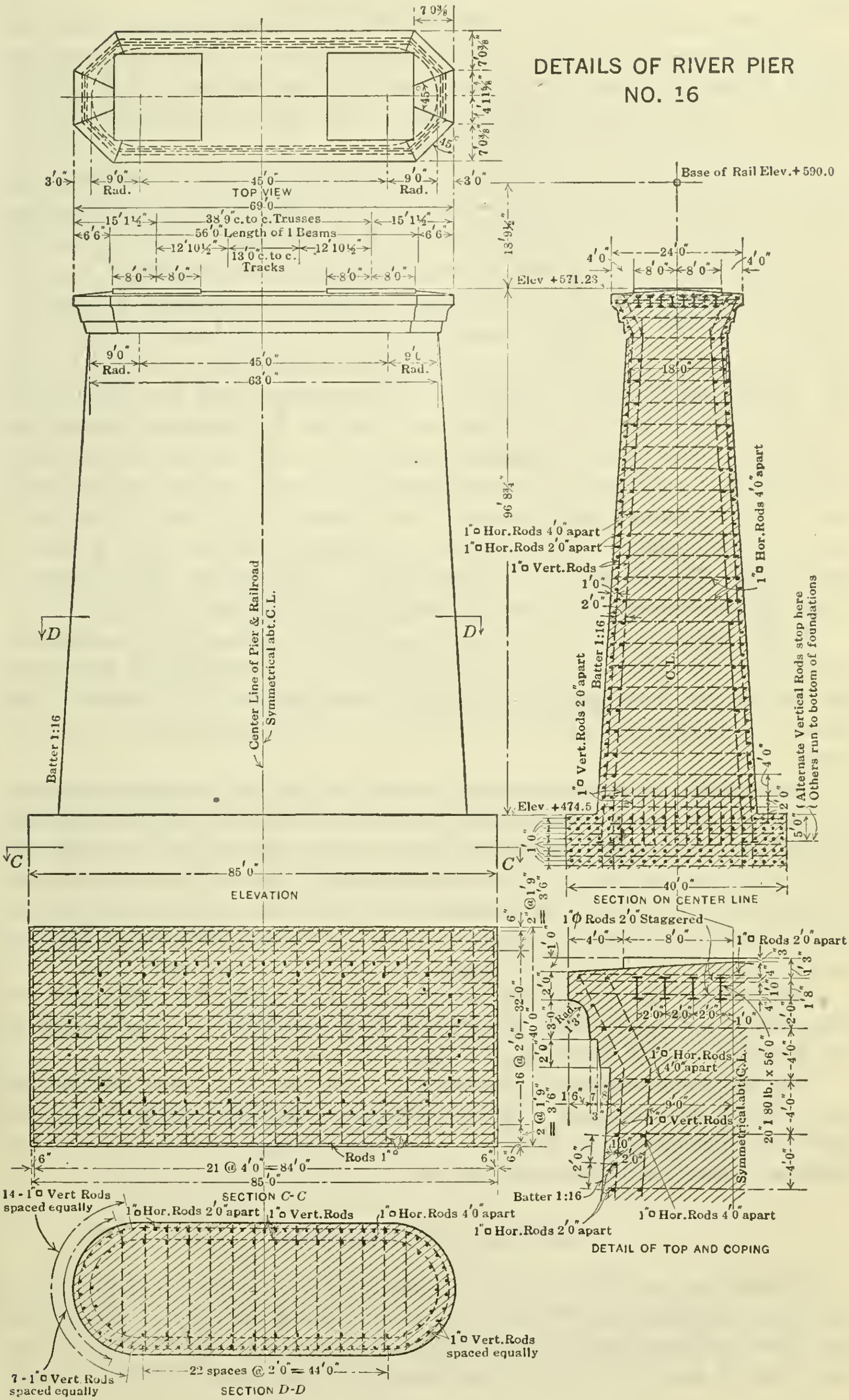

DETAILS OF RIVER PIER
NO. 16
TOP VIEW
ELEVATION
SECTION ON CENTER LINE
SECTION C-C
SECTION D-D
DETAIL OF TOP AND COPING
Base of Rail Elev.+590.0
Elev +571.23
Elev. +474.5
Center Line of Pier & Railroad
Symmetrical abt. C.L.
Batter 1:16
38'9" c. to c. Trusses
56'0" Length of I Beams
13'0" c. to c. Tracks
1" ▫ Hor. Rods 4'0" apart
1" ▫ Hor. Rods 2'0" apart
1" ▫ Vert. Rods
1" ▫ Vert. Rods 2'0" apart
Alternate Vertical Rods stop here
Others run to bottom of foundations
1" ϕ Rods 2'0" Staggered
1" ▫ Rods 2'0" apart
20 I 80 lb. x 56'0"
Rods 1" ▫
21 @ 4'0" = 84'0"
14 - 1" ▫ Vert Rods spaced equally
7 - 1" ▫ Vert. Rods spaced equally
1" ▫ Vert. Rods spaced equally
22 spaces @ 2'0" = 44'0"

FIG. 2.

The pier on the Ohio shore intersects the ground surface at mid-height of the embankment, about 30 ft. above low-water level. The foundation was placed during low water by dry open excavation through about 10 ft. of clay and 8 ft. of loose disintegrated shale rock. This pier was started in November, 1914, and completed in March, 1915.

The pier on the Kentucky shore is near the bottom of the embankment, where the ground surface is only about 15 ft. above low-water level and the soil is mostly sand. These conditions made it desirable to sink the pier as a concrete caisson with a steel cutting edge, a working chamber 6 ft. high, and four shafts 7 ft. 3 in. in diameter. It was not necessary, however, to resort to air pressure. All excavation down to the solid rock, about 15 ft. below low water, was done by open dredging with orange-peel buckets while the caisson was flooded. About 2 ft. of disintegrated rock was removed by hand, for which purpose the caisson was kept dry by pumping, having been carefully sealed with empty cement bags rolled up behind the cutting edge. As there was considerable seepage through the rock bottom, drain sumps were provided from which the water was pumped during the concreting of the working chamber. These sumps were finally filled by forcing cement grout down through pipes by compressed air. The cutting edge was set on June 22d, and the pier completed on September 14th, 1915.

At the middle or river pier, the rock surface is practically level and barely exposed at low water. The rock was excavated to a depth of 10 ft. to give the pier a firm hold against dislocation under possible ice pressure. This depth also proved necessary for the removal of all disintegrated and seamy rock.

Excavation and concreting were carried on within a wooden coffer-dam set on the rock bottom. This coffer-dam was 16 ft. high, 81 ft. wide, and 129 ft. long, and had double walls 10 ft. apart. The space between the walls was filled with dirt dredged from the river channel. The top was capped with 2-in. planking to prevent the washing out of the fill. Beams 8 ft. high were placed outside and inside, along the dam. Although submerged for four months during the high-water season, the coffer-dam remained intact.

Construction of the coffer-dam was started in November, 1914, and the pier was completed in May, 1915, after an interruption of four months in the foundation work during high water.

The three piers contain approximately 15 000 cu. yd. of concrete and 250 tons of steel reinforcement and cost $165 000, or $11 per cu. yd. They were built on contract by the Dravo Contracting Company, of Pittsburgh, Pa., with an average daily force of 105 men.

4.—Steel Superstructure

Rigidity was one of the main considerations in working out the design of the steel superstructure. With a few modifications, the rules of design were the same as those for the Hell Gate Arch Bridge and Approaches, and are contained in detail, with explanatory remarks, in the paper by O. H. Ammann,

M. Am. Soc. C. E., on that bridge.* They are, therefore, only briefly quoted here insofar as they apply specifically to the Sciotoville Bridge.

Loads and Stresses.—All stresses except those from wind and lateral forces were computed by the accurate theory of elasticity, considering the elastic deformation of all members after their section had been determined. The stresses from the wind and lateral force were computed by assuming a constant moment of inertia of the lateral truss. The assumed loads were as follows:

The dead load (D) was carefully calculated for each panel point after the general details had been fully worked out. A re-calculation of the weight from the shop drawings showed the assumed weight to be 3% in excess and, therefore, no re-calculation was made. The average dead load is 18 200 lb. per lin. ft. of bridge, which includes 1 400 lb. per lin. ft. assumed for the two tracks.

The live load (L) on each track was as shown on Fig. 3 (Cooper's E-60 loading).

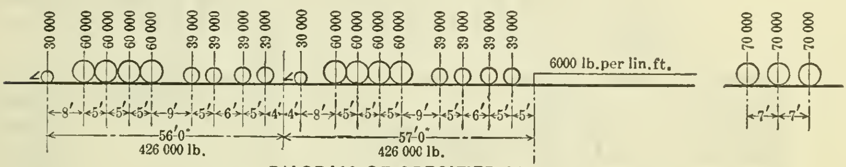


DIAGRAM OF SPECIFIED LIVE LOAD

FIG. 3.

In cases where the live load had to be separated, in order to produce maximum stress, the engine load was placed on the stretch producing the greater portion of the stress and a uniform load of 6 000 lb. per ft. of track on the stretch contributing the smaller portion.

The impact (I) was calculated according to Lindenthal's formula, as follows:

$$I = \frac{L}{D + L} \times \frac{1\,200 + \dfrac{a}{n}}{600 + 4\,a}$$

in which,

D = dead load stress, in pounds.

L = live load stress, in pounds.

a = length of train behind locomotive tender for position of maximum stress, in feet.

n = number of tracks loaded for maximum stress.

The lateral force (Lat.) from trains was 10% of the live load on one track, or Cooper's E-6 loading acting horizontally 5 ft. above the rail.

The wind pressure (W) was 800 lb. per lin. ft., stationary along the top chord, 700 lb. per lin. ft., stationary along the bottom chord, and 500 lb. per lin. ft., moving 7 ft. above the rail.

* *Transactions*, Am. Soc. C. E., Vol. LXXXII (1918), p. 852.

The longitudinal force (Br.) from braking or traction on one track only was 60 000 lb. on a wheel-base of 15 ft. for each locomotive, or 1 000 lb. per lin. ft. of track for the whole train.

The total stress was as follows: Members with dead and live load stress were proportioned for a total stress of $D + L + I +$ Lat. + Excess, in which Excess = (W and Br.) — 20% ($D + L + I +$ Lat.). Members free from dead or live load stress were proportioned for a total stress of $W +$ Br. + Lat.

The permissible unit stresses, in pounds per square inch, were as follows:

Tension, net section	20 000
Compression, net section	20 000

Gross section, $20\,000 - 100\left(\frac{l}{r} - 20\right)$ rounded up to the nearest 500 lb., in which l = the length and r = the radius of gyration of the whole section.

For latticed members, a further deduction of $100\left(\frac{l_1}{r_1} - 20\right)$ was made, in which l_1 = the length and r_1 = the radius of gyration of the unsupported portion of the section between lattice connections.

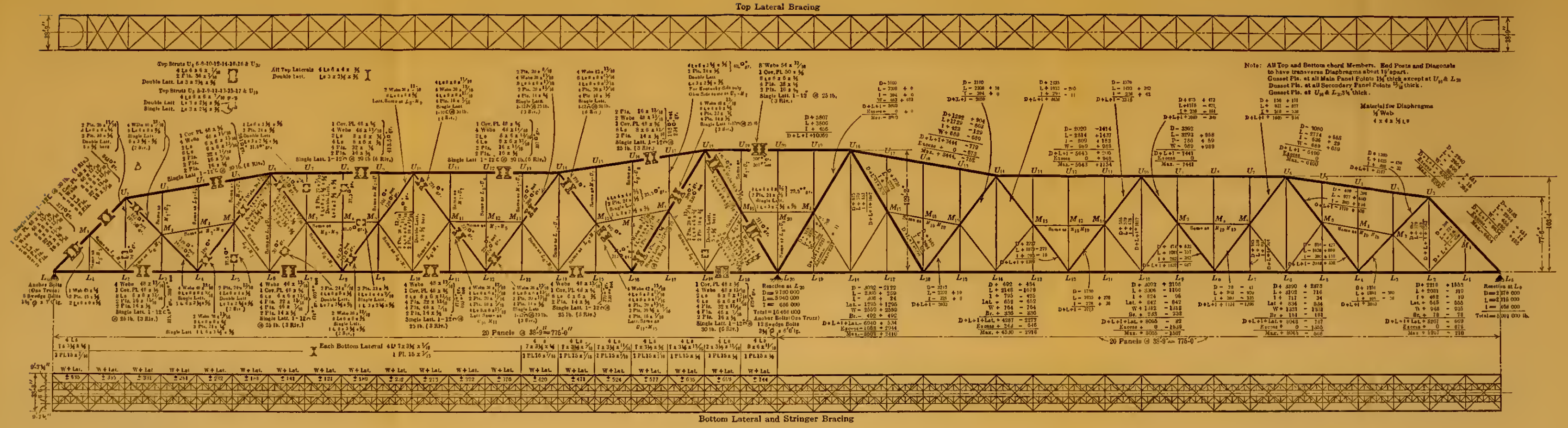
Bending on rolled shapes, girders, and steel castings, net section	20 000
Bending on pins	30 000
Shearing on webs, shop rivets, and pins	15 000
Shearing on field rivets and bolts	12 000
Bearing on shop rivets	25 000
Bearing on field rivets, turning-bolts and pins	20 000
Pressure on concrete masonry	600

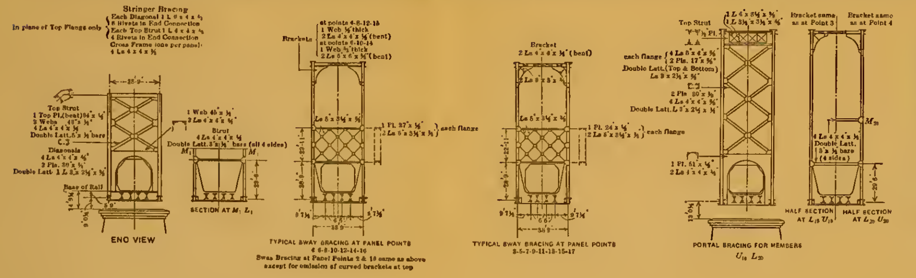
The specification for proportioning compression members differs somewhat from that used in the Hell Gate Bridge. The specified compression stress is applied to the gross instead of the net area of the section with the provision, however, that the stress applied to the net area shall not exceed 20 000 lb. per sq. in. The net area usually governed for members with $\frac{l}{r}$ less than 50.

Further, instead of different sets of unit stresses for different types of sections (closed section and sections with one or two open sides), the same basic stress was used for all sections, subject, however, to the previously stated deduction for latticed members.

General Proportions.—The steel superstructure, as built, is a double-track, two-span, continuous bridge, with a total length of 1 550 ft. between centers of end piers, or two equal spans of 775 ft. and two clear openings of 750 ft. at low-water level.

To obtain ample lateral rigidity, the width between centers of trusses was made 38 ft. 9 in., or one-twentieth of the span length, although at first a somewhat smaller width was considered sufficient, in view of the continuity of the lateral truss. The height at the middle of each span is 103 ft. 4 in. between centers of chords. To fix this height, the portion of the span between the end pier and the point of contraflexure was considered as a simple span. This portion varies from three-fourths of the span length for uniform load on both spans to seven-eighths of the span length for uniform load on one span





Assumed Dead Load Panel Concentrations per Truss in Units of 1000 lb.

Panel Points	Sum of Concentrations for Half Truss	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Steelwork at Upper Chord	2021.3	63.6	111	300	53.5	61.9	53	185	68.4	80	68.4	130.5	53.7	96.4	84	158.8	77.5	90	78	149.2	0	0
Steelwork at Middle Points	1154.5	11	219.8	0	148.5	24.4	132.3	0	108.6	22.0	89.0	0	64.5	22.6	49.8	0	59.6	21.2	68	0	120	0
Steelwork at Lower Chord	3552.2	176	153.2	199	155	251.7	172.7	168	132	225.1	157	196.5	157	200	157.2	196.7	157	187.8	126	148.8	120	146.5
Total Steelwork	6728	250.5	484	499	360	332	318	353	304	328	315	356	295	310	291	355	294	299	270	298	255	146.5
Flooring	540	13.5	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	13.5
Total Steelwork and Flooring	7268	264	511	526	387	365	345	380	331	355	342	383	322	337	318	382	321	326	297	325	282	160
Bearings																						

General Notes:

All Stresses are given in Units of 1000 lb.

D. denotes Dead Load
L. " Live Load
I. " Impact $\quad I = \frac{L^2}{D+L} \times \frac{1200+\frac{a}{n}}{600+4a}$
Lat. " Lateral force
W. " Wind
Br. " Braking

a = length in ft. of train behind Locomotive tender for position causing max. Stress
n = number of tracks

Excess = (W + Br.) − 20% (D + L + I + Lat.)

All field connections of stringers to floorbeams shall not be riveted until span is completely erected and self supporting

Size of Rivets

Trusses:
- All main members {shop = 1" dia. / field = 1" dia.} except at Points U_{18} L_{20} = 1¼" dia.
- Sub diagonals, main & sub hangers {shop = ⅞" dia. / field = 1" "}
- Long secondary posts {shop = ⅞" dia. / field = ⅞" "} {except in connection for Bott. Chord Gussets = 1" dia.}
- For balance of truss members & bracing {shop = ⅞" / field = ⅞"}

Floorsystem {shop = ⅞" dia. / field = ⅞" dia.} {except for the end connections of Floorbeams and stringers = 1" dia.}

Computation of Stresses

All stresses determined by assuming main trusses and bottom lateral truss as continuous over three supports and top lateral trusses as simple spans between U_2 and U_{18}

STRESS AND SECTION SHEET

only and averages 630 ft. in length. The height of the truss was chosen approximately one-sixth of this length.

The height over the center pier is 129 ft. 2 in., or one-sixth of the span length; this is the proper height for a simple span of the same length, which has the same maximum moment at the center as the two-span continuous bridge over the middle support.

The height at the end was made 77 ft. 6 in., or equal to a double panel, in order to give the end posts an inclination of not less than 45 degrees. These heights also secured a pleasing outline for the top chord. The web system is of the Warren type, with subdivided panels of a uniform length of 38 ft. 9 in., which was found to be the most economical.

Truss Members and Connections.—Two preliminary designs of the trusses were made, one with tension members built up of pin-connected, 16-in. eye-bars and one with riveted members and riveted connections throughout. In the first design, all riveted members had riveted connections as most of them had to be designed for reversal of stress and no pin connections were allowed for such members. This design was unusual, in that the eye-bars in the heavier tension members were arranged in two chains, one above the other, each consisting of two sets of bars corresponding to the two webs or gussets of the riveted members.

The principal panel points were carefully detailed for both designs, and it was found that they were feasible, although requiring unusual connections and gussets of the largest practicable sizes.

Bids were asked on both designs. The eye-bar design, although about 200 tons lighter, proved to be only slightly cheaper, according to the lowest bid. The riveted truss design was finally adopted, in view of its superior rigidity, durability, and safety. The Sciotoville Bridge is, therefore, the largest truss bridge with completely riveted connections.

The advantages of pin-connected bridges, namely, cheaper fabrication and quicker erection, are not as important to-day as they were formerly. With the present improved facilities for punching, drilling, riveting, etc., the cost of manufacture and erection of riveted work has been greatly decreased, and the time of erection is a less important factor than in the pioneer days of rapid railroad construction.

Typical sections of the truss members are shown on the stress sheet (Plate V). All members have double webs and all chords and main diagonals have inside and outside flange angles. Both top and bottom chords and the inclined end posts have one solid cover-plate on top. The bottom flange angles of the same web are connected by a flange plate which distributes the stress from the latticing to both angles. The inclined posts at the center pier have a solid cover, top and bottom, and thus form completely closed boxes.

All the open sides of the members have exceptionally strong latticing, ranging from 3 by $2\frac{1}{2}$ by $\frac{3}{8}$-in. angles, with two rivets, to 12-in. by 30-lb. channels with six rivets. For compression members, the latticing has been proportioned for a transverse shearing force, in pounds, equal to three hundred times the gross area of the member, in square inches. The members are stiffened against distortion by transverse diaphragms about 15 ft. apart.

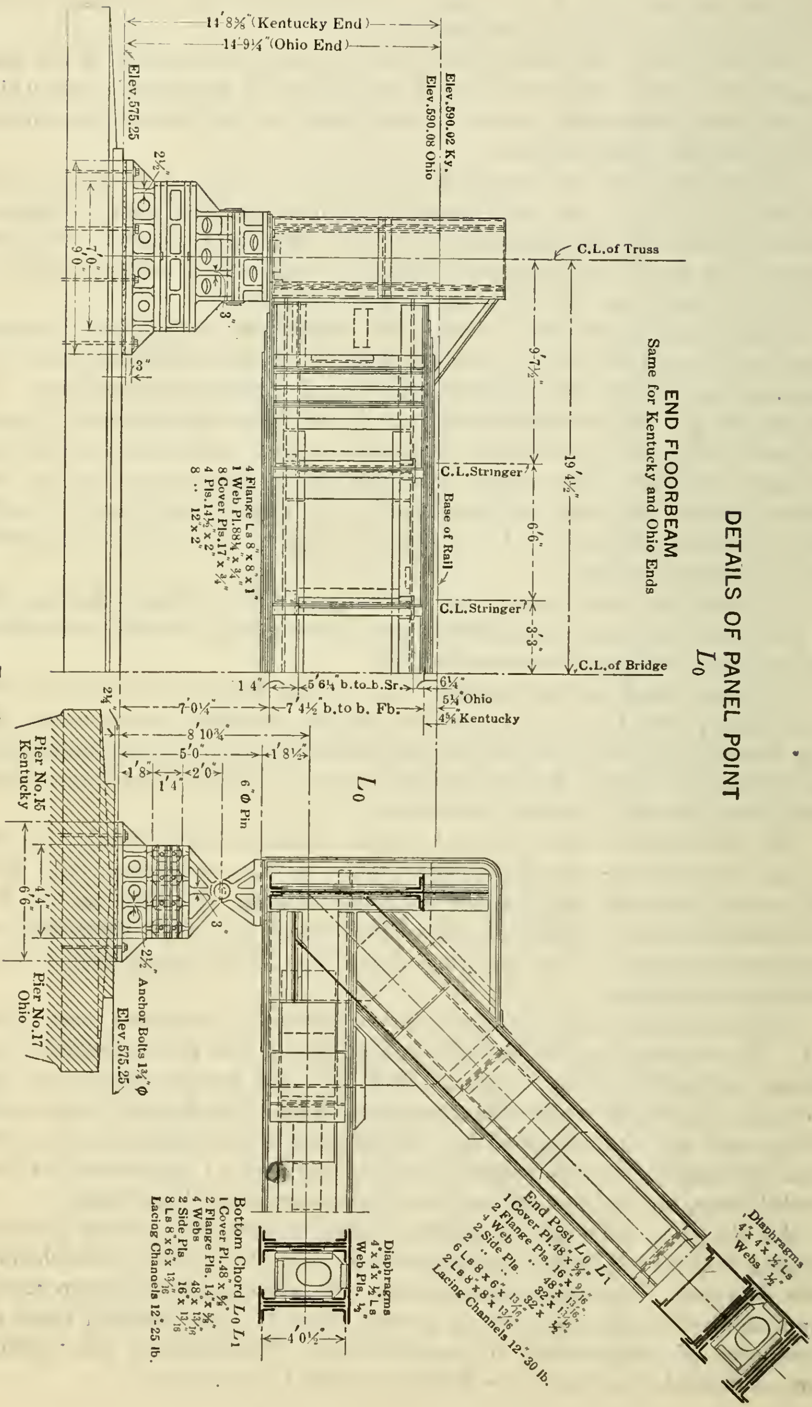

DETAILS OF PANEL POINT L_0
END FLOORBEAM
Same for Kentucky and Ohio Ends
14′-8⅜″ (Kentucky End)
14′-9¼″ (Ohio End)
Elev. 575.25
Elev. 590.92 Ky.
Elev. 590.08 Ohio
C.L. of Truss
C.L. Stringer
Base of Rail
C.L. Stringer
C.L. of Bridge
9′-7½″
19′-4½″
6′-6″
3′-3″
4 Flange Ls 8″ x 8″ x 1″
1 Web Pl. 88¾″ x ¾″
8 Cover Pls. 17″ x ¾″
4 Pls. 14½″ x 2″
8 „ 12″ x 2″
1′ 4″
5′ 6¼″ b. to b. Sr.
6¼″
5¼″ Ohio
4⅝″ Kentucky
7′-0¼″
7′ 4½″ b. to b. Fb.
8′ 10¾″
5′-0″
1′ 8½″
1′ 8″
1′ 4″
2′ 0″
6″ Φ Pin
L_0
Pier No. 15
Kentucky
Pier No. 17
Ohio
4′ 4″
6′ 6″
Anchor Bolts 1¾″ Φ
Elev. 575.25
End Post L_0 L_1
1 Cover Pl. 48″ x ⅝″
2 Flange Pls. 16″ x 9/16″
4 Web „ 48″ x 13/16″
2 Side Pls. 32″ x ⅝″
2 „ „ 32″ x ½″
6 Ls 8″ x 6″ x 13/16″
2 Ls 8″ x 8″ x 13/16″
Lacing Channels 12″-30 lb.
Diaphragms
4″ x 4″ x ½″ Ls
Webs ½″
Bottom Chord L_0 L_1
1 Cover Pl. 48″ x ⅝″
2 Flange Pls. 14″ x ⅝″
4 Webs 48″ x 13/16″
2 Side Pls. 16″ x 13/16″
8 Ls 8″ x 6″ x 13/16″
Lacing Channels 12″-25 lb.
Diaphragms
4″ x 4″ x ½″ Ls
Web Pls. ½″
4′ 0½″

FIG. 4.

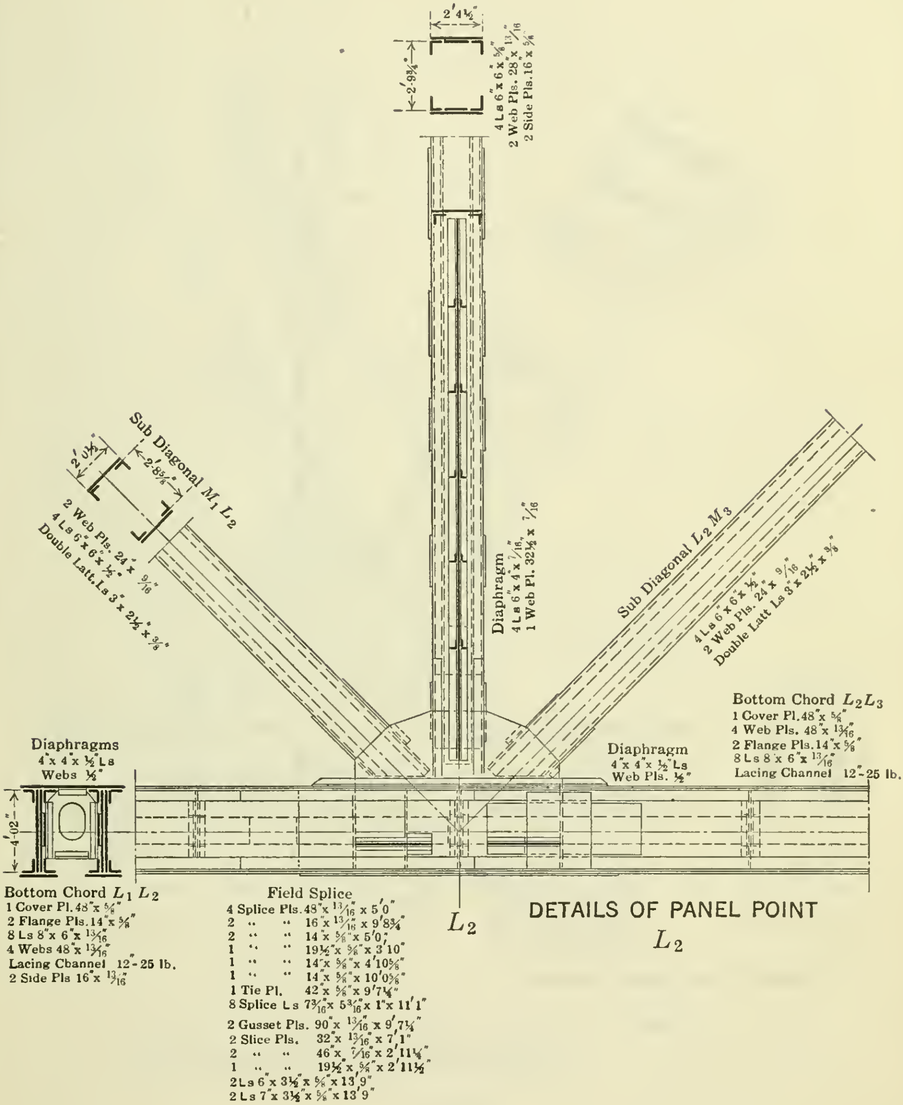
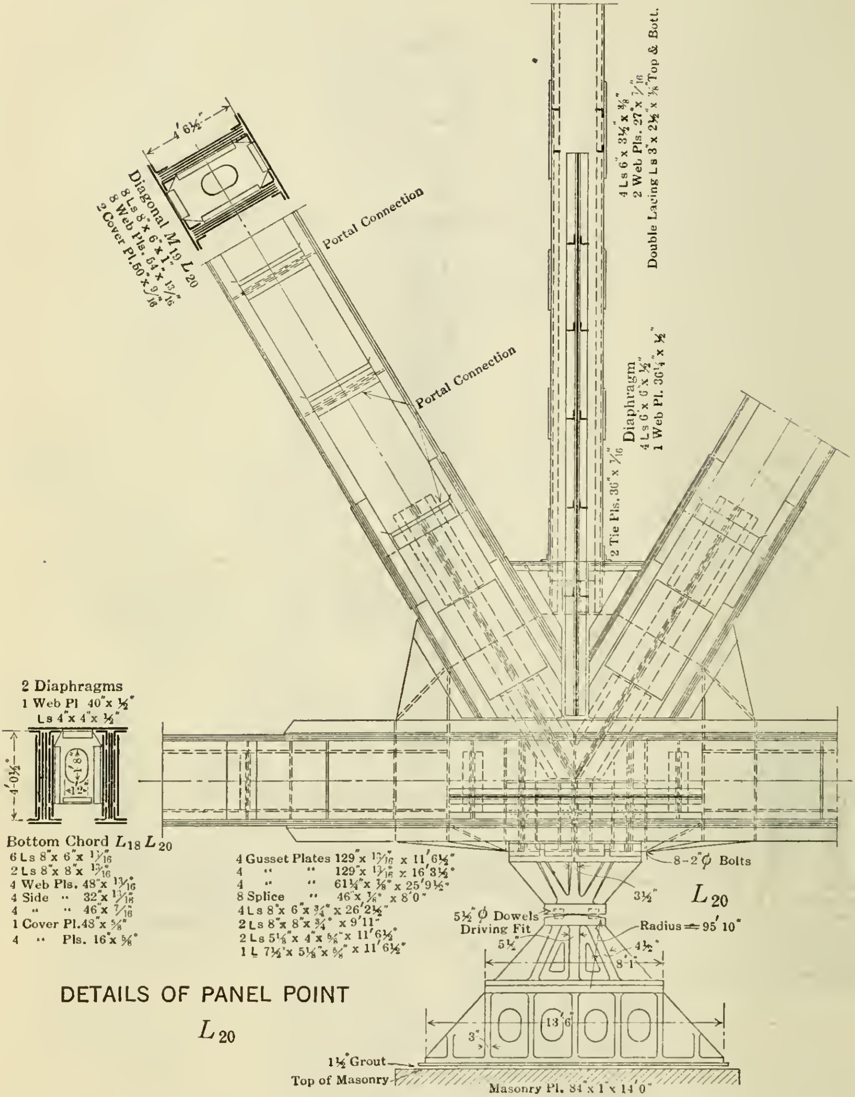


Fig. 5.

The gusset-plates are in the plane of the web-plates of the members, the latter being cut at the edge of and spliced to the gussets in such a manner that the rivets are in double shear. The flange angles extend in all cases over the gussets.

The gusset-plates at the main panel points are 1⅝ in. thick, except at panel points, U 18 and L 20, where they have a maximum thickness of 3¼ in. The gussets at the secondary panel points are 1⅜ in. thick. Correspondingly,



DETAILS OF PANEL POINT

L_{20}

Fig 6.

the webs of the main members are $\frac{13}{16}$, $1\frac{5}{8}$, and $3\frac{1}{4}$ in. thick, all being made up of individual plates, $\frac{13}{16}$ in. thick. This uniformity greatly facilitated the detailing of the connections and the avoiding of fillers.

As the full thickness of the gussets was not required for the full size, at some of the largest connections the gussets were split into two to four plates, $\frac{13}{16}$ in. thick, of variable size, in order to save weight. The largest gusset-plates used are 135 in. by $1\frac{5}{8}$ in. by 14 ft. 9 in., and 140 in. by $\frac{13}{16}$ in. by 18 ft. 2 in.

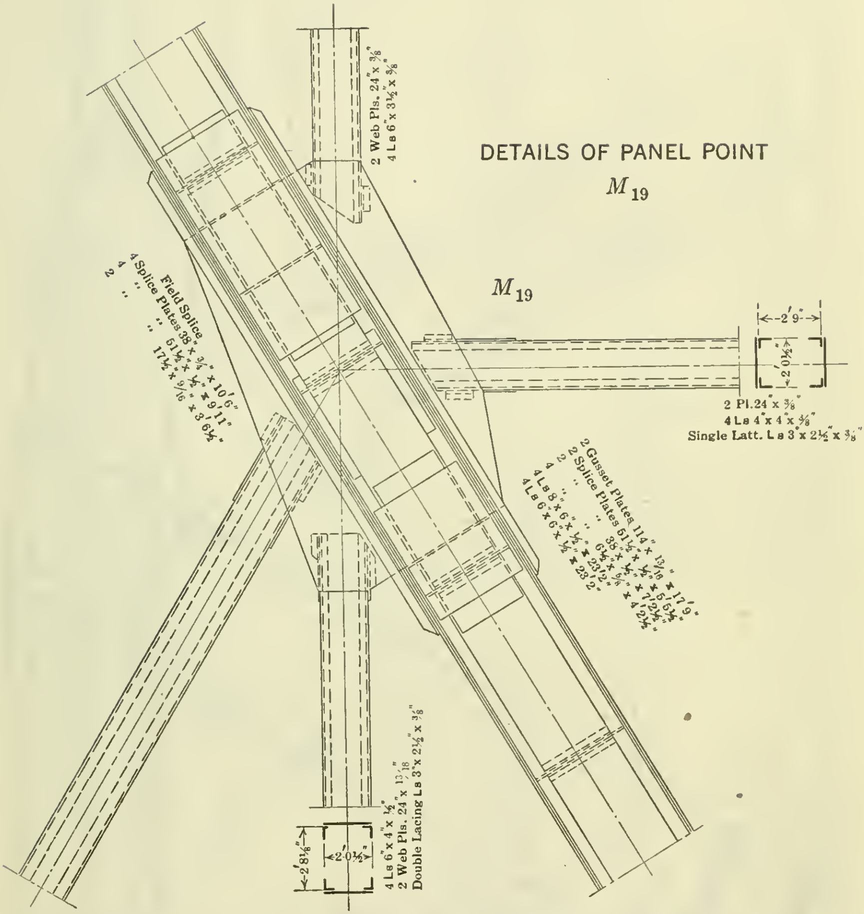


FIG. 7.

All chords are fully spliced. In the Ohio span, which was erected on false-work, the splices are arranged at every second panel point, and on the Kentucky side at every panel point for convenience in the cantilever erection.

All shop and field rivets of the main truss members are 1 in. in diameter, except at panel points, U 18 and L 20, where they are 1¼ in. in. diameter and up to 7⅜ in. long between heads. The secondary members have ⅞-in. shop and 1-in. field rivets. Figs. 4, 5, 6, 7, and 8 show typical connections and splices.

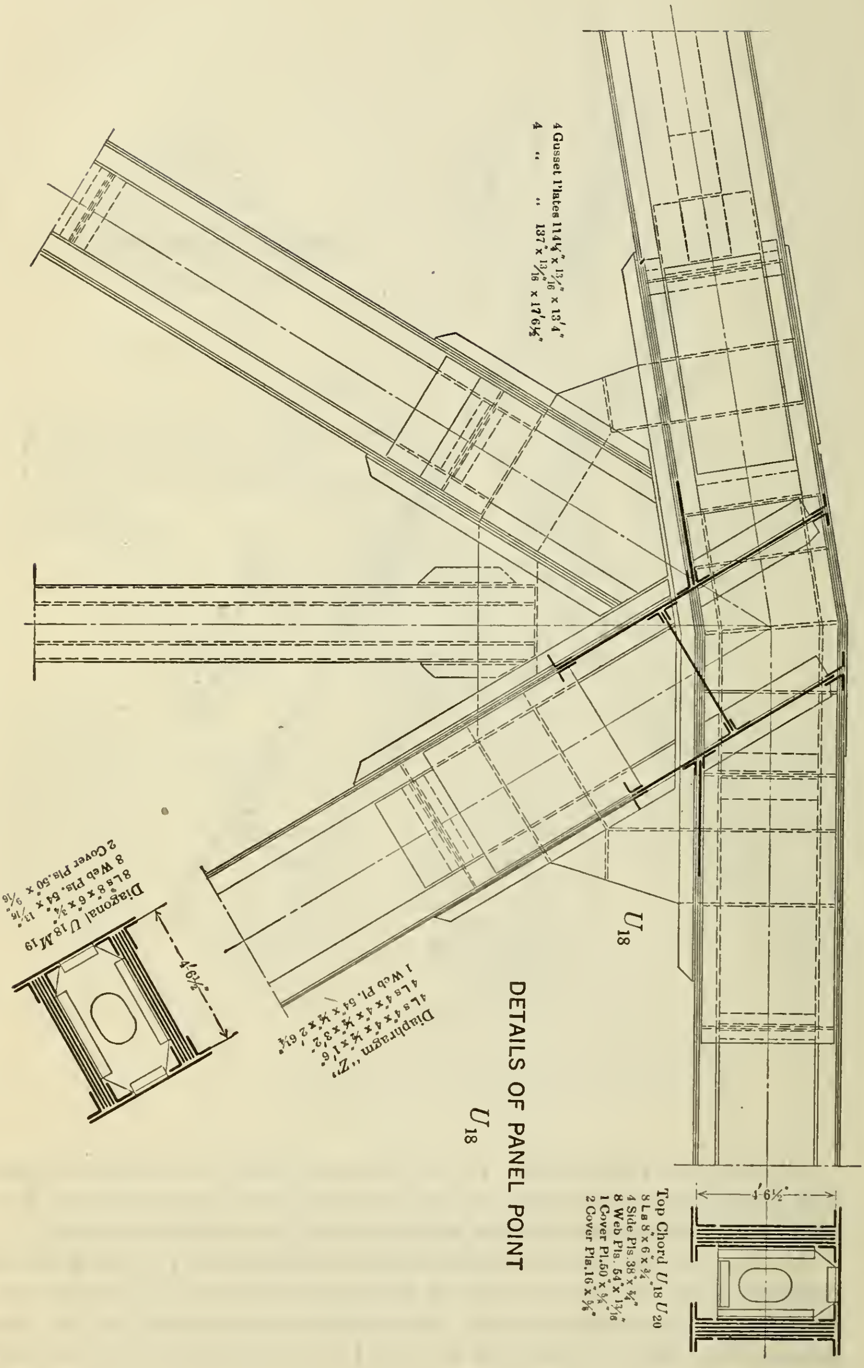
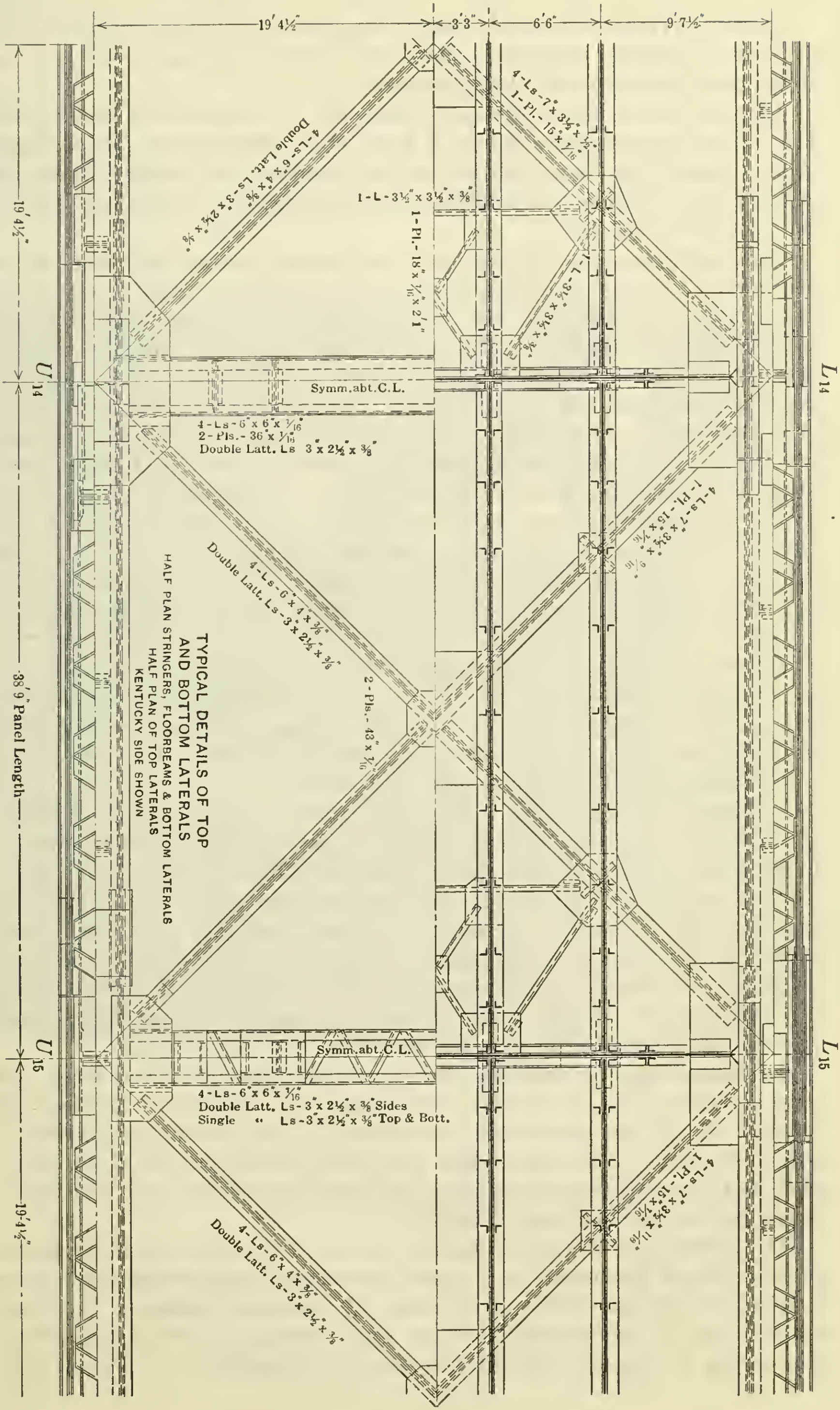

4 Gusset Plates 114¼" x 13/16" x 13'4"
4 " " 137" x 13/16" x 17'6½"
U18
DETAILS OF PANEL POINT
U18
Top Chord U18 U20
8 Ls 8" x 6" x ¾"
4 Side Pls. 38" x ¾"
8 Web Pls. 54" x 13/16"
1 Cover Pl. 50" x ⅝"
2 Cover Pls. 16" x ⅝"
4'-6½"
Diagonal U18 M19
8 Ls 8" x 6" x ¾"
8 Web Pls. 54" x 13/16"
2 Cover Pls. 50" x 9/16"
4'-6½"
Diaphragm "Z"
1 Web Pl. 54" x ½" x 2'6¼"
4 Ls 4" x 4" x ½" x 3'2"
4 Ls 4" x 4" x ½" x 1'6"

FIG. 8.



19′ 4½″
3′ 3″
6′ 6″
9′ 7½″
19′ 4½″
38′ 9″ Panel Length
19′ 4½″
4-Ls-6″ x 4″ x 3/8″ Double Latt. Ls-3″ x 2½″ x 3/8″
4-Ls-7″ x 3½″ x ½″ 1-Pl.-15″ x 7/16″
1-L-3½″ x 3½″ x 3/8″
1-Pl.-18″ x 7/16″ x 2′ 1″
1-L-3½″ x 3½″ x 3/8″
U14
L14
Symm.abt.C.L.
4-Ls-6″ x 6″ x 7/16″
2-Pls.-36″ x 7/16″
Double Latt. Ls 3″ x 2½″ x 3/8″
4-Ls-7″ x 3½″ x 9/16″ 1-Pl.-15″ x 7/16″
4-Ls-6″ x 4″ x 3/8″ Double Latt. Ls-3″ x 2½″ x 3/8″
2-Pls.-43″ x 7/16″
TYPICAL DETAILS OF TOP AND BOTTOM LATERALS
HALF PLAN STRINGERS, FLOORBEAMS & BOTTOM LATERALS
HALF PLAN OF TOP LATERALS
KENTUCKY SIDE SHOWN
U15
L15
Symm.abt.C.L.
4-Ls-6″ x 6″ x 7/16″
Double Latt. Ls-3″ x 2½″ x 3/8″ Sides
Single " Ls-3″ x 2½″ x 3/8″ Top & Bott.
4-Ls-7″ x 3½″ x 11/16″ 1-Pl.-15″ x 7/16″
4-Ls-6″ x 4″ x 3/8″ Double Latt. Ls-3″ x 2½″ x 3/8″

FIG. 9

Bracing.—There is a lateral system along the bottom chords forming with the latter a two-span continuous truss. The laterals pass under and are connected to the bottom flange of the stringers.

There is also a lateral system between the top chords from end to end. The portions between panel points, U 2 and U 8, are assumed to act as simple spans, transmitting the end shears at these points to the portals between the inclined posts. The laterals and struts of this system are of the full depth of the top chord (Fig. 9).

The portals between the end posts and between the inclined posts at the center pier are very rigid. The upper part consists of rigid single intersection braces and the lower one of a solid plate-girder arch (Fig. 10).

Sway-frames between the other web members have been purposely omitted as being unnecessary and as they would have had to be made very strong to resist unequal deflections of the trusses. Instead, there is a lattice frame at every panel point which acts as a lateral brace for the long web members and, at the same time, as a strut between the upper ends of the U-shaped floor-beam, the latter acting as an inverted arch as described later.

The longitudinal struts which brace the long verticals at mid-height, extend over two panels for better appearance. They were also useful in the cantilever erection of the Kentucky span. After erection, the connection at one end was loosened so as to allow it to slide and thus prevent the introduction of indeterminate stresses.

Bearings.—All bearings are of cast steel. The bearings at the center pier are fixed; those at the ends are movable. The longitudinal force from braking and traction is thus transmitted to the center pier which carries about 60% of the vertical load of the entire bridge, the longitudinal expansion of the bridge being divided between the two end bearings.

The center bearing of each truss carries a total vertical load of 16 406 000 lb., inclusive of impact, and it transmits, further, a longitudinal force of 2 520 000 lb. It consists of the shoe-casting (Fig. 11), bolted to the truss, and a pedestal made up of three individual castings arranged in two tiers. The truss transmits its reactions to the shoe in direct bearing by the gussets which, for this purpose, are extended somewhat below the bottom chord. The upper surface of the shoe-casting is planed slightly convex parallel to the truss to prevent dangerous edge pressure, although the casting has been proportioned by assuming the load as distributed uniformly over its full length.

To concentrate the reactions and permit the truss to deflect freely, the lower surface of the shoe-casting was planed to a cylindrical surface with a radius of 1 150 in., whereas the top surface of the pedestal was finished to a perfect plane. Under maximum load, the contact area is about 8½ in. wide, and the greatest pressure along the center line of this area is 29 900 lb. per sq. in., the average being 23 300 lb.

The reactions of the bottom lateral truss are transmitted from the lateral gussets through diaphragms to a lateral extension of the shoe-casting in order to relieve the gussets of the main trusses of transverse bending. The longitudinal force is transmitted from the main gussets to vertical lugs of the shoe-casting by means of turned bolts 2½ in. in diameter. To prevent hori-

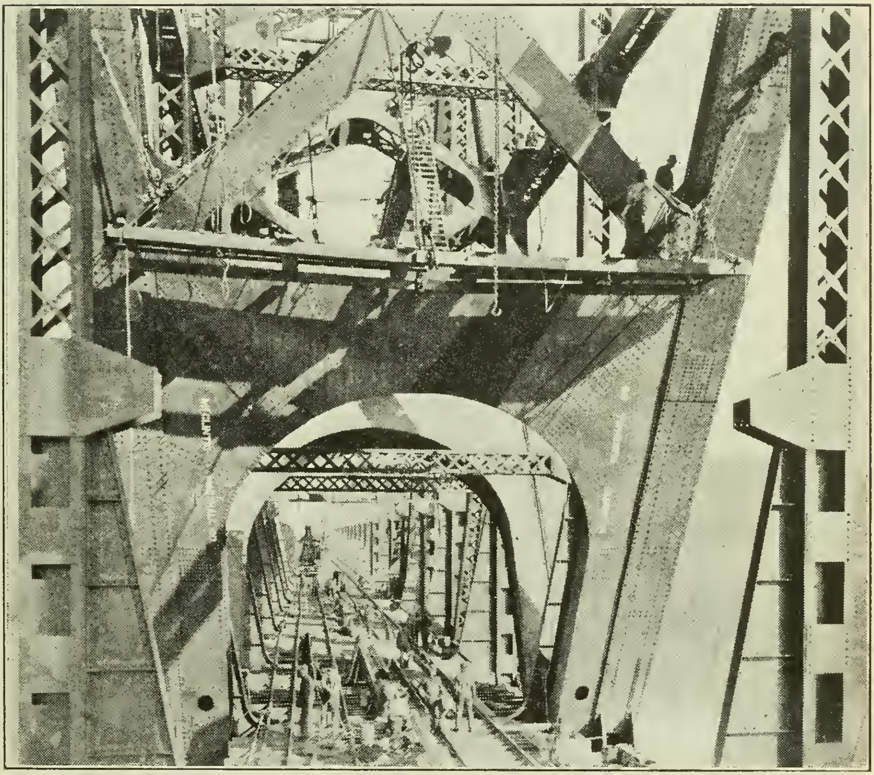


FIG. 10.—BOX GIRDER PORTALS BETWEEN DIAGONALS OVER CENTER PIER, SCIOTOVILLE BRIDGE.

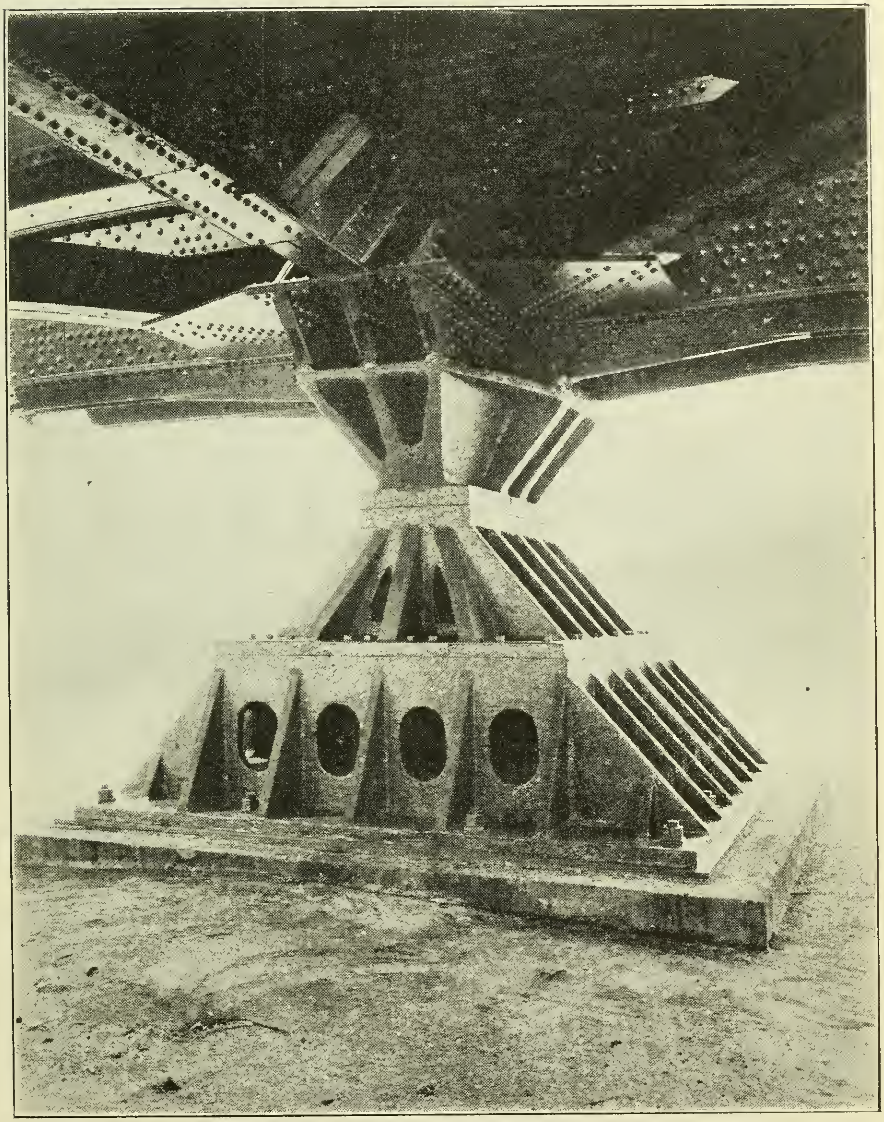
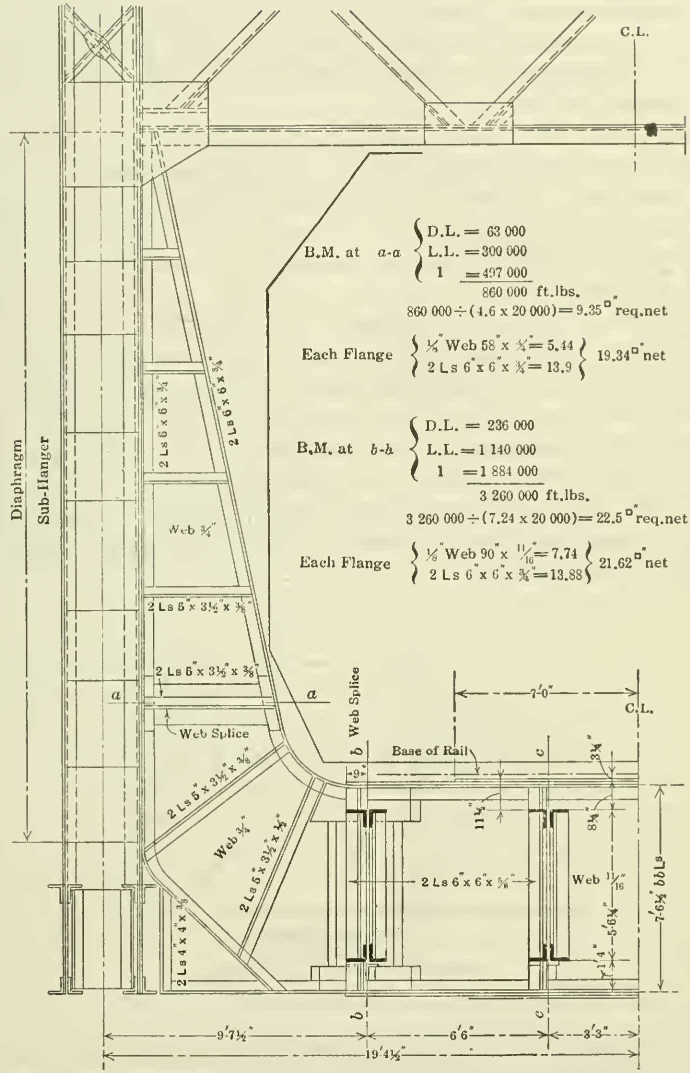


FIG. 11.—STEEL CASTING ON CENTER PIER, SCIOTOVILLE BRIDGE.



INTERMEDIATE FLOORBEAM

Assumed Wind, Lateral & Braking Force

Wind along Top Chord = 800 lb. per lin.ft.of Bridge
" " Bottom Chord = 700 " " " " " "
" on Train = 500 " " " " " "
Lateral Force from Train = 10% of Live Load (E.60) on one Track
Braking Force = 1000 lb. per lin.ft.of Bridge on one Track
or: $1000 \frac{25.875}{38.75}$ = 670 lb. per lin.ft.of one Truss

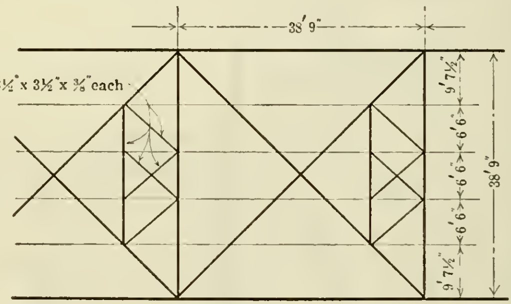
FIG. 12.

zontal motion, the shoe-casting is secured to the pedestal by four steel dowels 6 in. in diameter.

The complete bearing weighs 75 tons and the heaviest individual casting, 21 tons. The end bearings are much lighter and are of the ordinary type with a pin 6 in. in diameter and a nest of rockers 16 in. high. Each end bearing weighs, complete, 20 tons.

Floor System.—The tracks are carried by four lines of stringers of the usual plate-girder type, which are framed into the floor-beams.

The floor-beams, however, are of exceptional design. They form U-shaped frames (Fig. 12), extending up to the bottom of the overhead struts. The available height of the floor was too shallow for an economical and stiff floor-beam of the ordinary type computed as a simple span between centers of trusses. There was, however, sufficient room available outside the train-clearance line for wide, deep brackets. By making the latter continuous with the floor-beam proper, it became admissible to compute the stresses by assuming the frame as an inverted two-hinged arch. This reduced the bending moments in the horizontal portion considerably and effected a substantial saving in weight. The overhead strut takes up the horizontal thrust of the inverted arch. The whole arrangement is contributive to stiffness and resistance to vibration, and the bridge behaves most satisfactorily in that regard under heavy trains.



BRAKING TRUSS
(one in each Panel)
(in Plane of Bottom Flange of Stringers)

FIG. 13.

Braking Trusses.—In large bridges, traction or braking trusses are necessary to avoid excessive horizontal bending of the floor-beams by the longitudinal forces. In the Sciotoville Bridge, this has been solved in a novel way by providing such a truss in every panel in the plane of the bottom laterals (Fig. 13). In this manner, the stresses in the stringers from the longitudinal force are reduced to a negligible minimum and the horizontal bending of the floor-beams from that force and from the deformation (changes in length from tension and compression) of the bottom chords, is avoided.

No expansion joints are provided in the floor. This feature introduces high longitudinal stresses in the stringers from the deformation (extension

and compression) of the bottom chords. To reduce these stresses to the effect of the live load, the length of the stringers was made to correspond with the length of the bottom chords under full dead load.

The stringer connections were not riveted until the spans had been swung. Even so, it was found necessary to increase the number of rivets in the stringer connections above that required for the vertical shear, by about 20%, or rather the diameter was increased from $\frac{7}{8}$ in. to 1 in. To avoid these high stresses in the stringer connections altogether, provision for an expansion joint in each panel was considered, but it was found that the additional expense for the expansion seats for the stringers would have been considerable and, moreover, the rigidity of the floor would have been greatly impaired.

An arrangement with only four expansion joints, eight panel lengths, or 310 ft., apart, with a braking truss in the middle between two joints, was also considered. Its advantage was a slight saving in weight of braking trusses and comparatively small stresses in the stringers and floor-beams, both from the longitudinal forces and the deformation of the bottom chords. In this case, however, it was not proper to connect the floor laterals rigidly to the stringers, because the deformation of the chords would be transmitted to the stringers through the laterals, and thus severely strain the latter and their connections to the stringers. To omit these connections would increase the weight and decrease the rigidity of the lateral system, which together with the undesirability of expansion joints, finally decided in favor of the adopted scheme.

Deflections, Camber, and Secondary Stresses.—The greatest live load deflections of the trusses are 3 in. from full load covering both spans and $4\frac{5}{8}$ in., or about 1:2000 of the span length, from full load covering only one span (Fig. 14). This is about the same as the deflection of a corresponding simple span having a height between one-sixth and one-seventh of the span length.

As was expected, the deflection polygon showed a rather sharp upward kink at the middle support and indicated high secondary stresses in the vicinity of this support. This was corroborated by a calculation of these stresses, which was made both for full load on one span only and for full load on both spans.

Without provision for reducing them, the largest secondary stresses would be 13 300 lb. per sq. in. from dead load, and 8 100 lb. per sq. in. from live load, or a total of 2 400 lb. per sq. in. in the bottom chord next to the center bearing, and 5 500 lb. per sq. in. from dead load, and 3 300 lb. per sq. in. from live load, or a total of 8 800 lb. per sq. in. in the inclined posts at the center pier. In view of this, and on account of the rigid truss connections, it was considered advisable to reduce the secondary stresses as far as possible, not only near the center support, but throughout the truss, in the chords as well as in the web members. This was done by cambering the trusses for full dead load plus one-half the live load, covering both spans, but assembling and erecting them so that the angles between the members and the bevels of the joints would correspond to the geometric form of truss. In other words, under

the load $\left(d + \frac{1}{2}\ l\right)$, the trusses are calculated to assume their true geometric form and the members to become straight and free of secondary stresses.

The secondary stresses from dead load are thus eliminated and those from live load are halved or, more properly expressed, the secondary stresses under dead load only are equal, but of opposite sign, to those under full live load covering both spans, and, in absolute value, equal to one-half of those which would be produced by full live load if the angles between the members would correspond to the cambered form of truss. The largest secondary stresses, previously mentioned, are thus reduced to 4 000 lb. per sq. in. in the bottom chord and to 1 650 lb. per sq. in. in the inclined posts, which stresses are fully covered by the margin of safety of the direct stresses.

In order to secure the greatest safety during erection, and because no reliance was placed on the turning of the ends of the truss members as the erection proceeded, it was decided to follow the erection of the members with the riveting as soon as practicable and before the members would take any appreciable stress. This meant initial bending of all truss members for making their connections, which was accomplished partly by drifting and partly by special jacking operations.

This is the first bridge, in which this method of reducing secondary stresses in all members has been used. It is a great improvement on previous practice, in which secondary stresses were assumed to take care of themselves, at the risk of overstressing the metal at the connections.

Steel Weights.—The entire bridge of two continuous spans, each 775 ft. long, contains 13 240 tons of steelwork, as follows:

	Total weight, in pounds.	Weight per 1 ft. of bridge, in pounds.
Floor system........................	3 403 200	2 200
Floor lateral bracing.................	732 400	475
Overhead bracing.....................	1 942 400	1 250
Trusses	19 947 400	12 880
Bearings	456 200	295
Total steelwork	26 481 600	17 100

The weight of the metal in the two riveted simple girder spans, each 775 ft. long, of the usual type, and for the same live load, would have been 16 000 tons, or 20% heavier than the design herein described and as built, not counting considerable extra metal which would have been required for the erection of the channel span by the cantilever method.

As the proportion of dead load to live load in these continuous spans is as 3 : 2, an increase of live load from E-60 to E-75 would increase the total stresses from dead plus live load on the average only 10 per cent. That leaves a large margin of safety for the heavier loading if it is ever used.

The truss span nearest in length is the 720-ft., double-track, simple girder span of the Ohio River Bridge at Metropolis. The metal weighs 8 023 500 lb., or 11 200 lb. per lin. ft. of bridge, the light weight being due to alloy steel, eye-bars instead of riveted tension members, and the use of higher unit stresses.

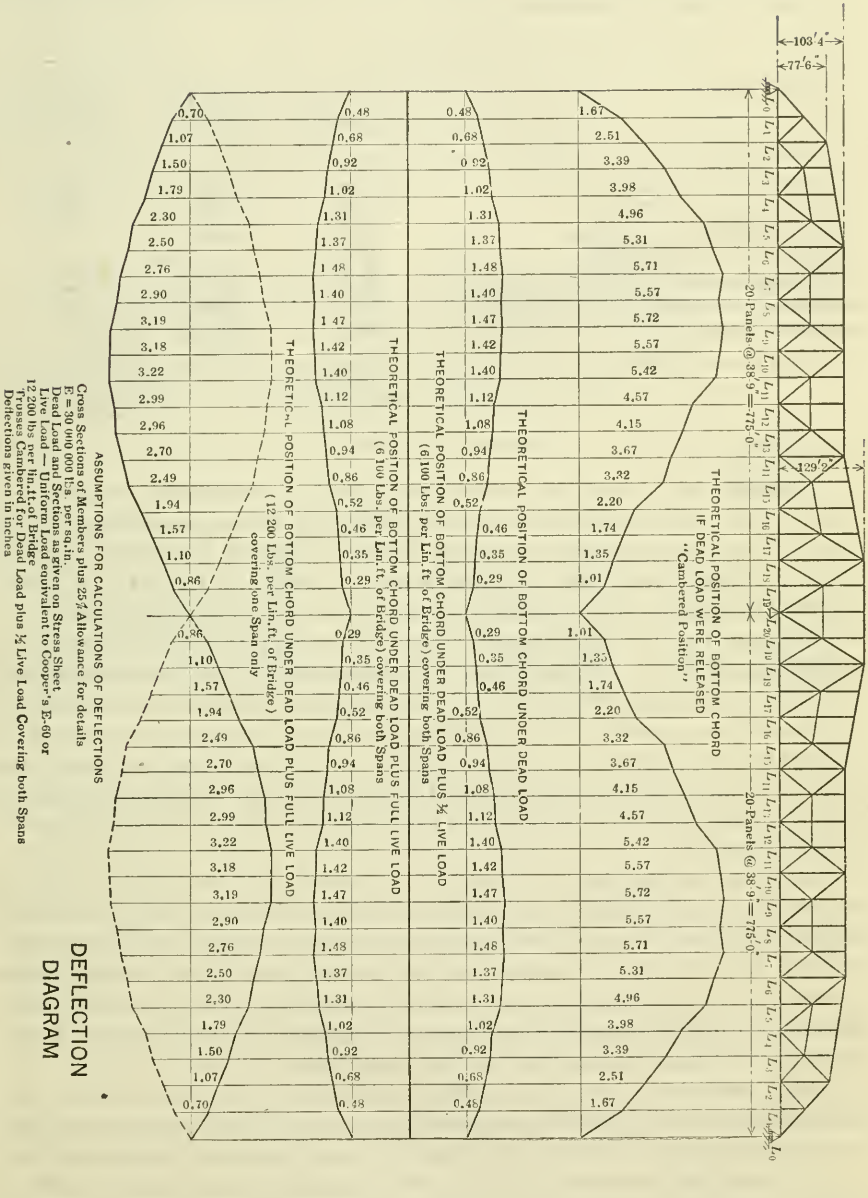

DEFLECTION DIAGRAM
THEORETICAL POSITION OF BOTTOM CHORD IF DEAD LOAD WERE RELEASED "Cambered Position"
THEORETICAL POSITION OF BOTTOM CHORD UNDER DEAD LOAD
THEORETICAL POSITION OF BOTTOM CHORD UNDER DEAD LOAD PLUS ½ LIVE LOAD (6 100 Lbs. per Lin.ft of Bridge) covering both Spans
THEORETICAL POSITION OF BOTTOM CHORD UNDER DEAD LOAD PLUS FULL LIVE LOAD (6 100 Lbs. per Lin.ft. of Bridge) covering both Spans
THEORETICAL POSITION OF BOTTOM CHORD UNDER DEAD LOAD PLUS FULL LIVE LOAD (12 200 Lbs. per Lin.ft. of Bridge) covering one Span only
20-Panels @ 38′ 9″ = 775′ 0″
20-Panels @ 38′ 9″ = 775′ 0″
103′ 4″
77′ 6″
129′ 2″
ASSUMPTIONS FOR CALCULATIONS OF DEFLECTIONS
Cross Sections of Members plus 25% Allowance for details
E = 30 000 000 lbs. per sq.in.
Dead Load and Sections as given on Stress Sheet
Live Load — Uniform Load equivalent to Cooper's E-60 or
12 200 lbs per lin.ft.of Bridge
Trusses Cambered for Dead Load plus ½ Live Load Covering both Spans
Deflections given in inches

FIG. 14.

5.—Fabrication and Erection of Steelwork

Quality of Steel.—All parts, except the rivets and the cast-steel bearings, are of open-hearth structural steel. The chemical and physical requirements for the various grades are as given in Table 1.

TABLE 1.

	Structural steel.	Rivet steel.	Cast steel.
Phosphorus, maximum basic	0.04	0.04	0.05
" " acid	0.06	0.04	0.08
Sulphur, maximum	0.05	0.04	0.05
Ultimate strength, in pounds per square inch, maximum	70 000	58 000	......
Ultimate strength, in pounds per square inch, desired	66 000	......	......
Ultimate strength, in pounds per square inch, minimum	62 000	50 000	65 000
Yield point, minimum	35 000	28 000	33 000
Elongation, minimum { in 2 in. for cast steel; in 8 in. for other steel	22%	28%	20%
Character of fracture	Silky	Fine silky	Silky or fine granular.
Cold bend without fracture	180° around pin of thickness of test piece.	180° flat	90° around pin three times thickness of test piece.

Workmanship.—The principal requirements for workmanship were as follows: Punching was allowed to full size of the hole in the material up to ½ in. thick; to $\frac{3}{16}$ in. smaller than the finished hole in material up to ⅝ in. thick; to $\frac{11}{16}$ in. in diameter for rivets ⅞ in. and more, in material $\frac{11}{16}$ in. and ¾ in. thick; and to ¾ in. in diameter for rivets 1 in. and more, in material $\frac{13}{16}$ in. thick.

All holes punched small had to be reamed or drilled to full size after the assembling of parts. All other holes had to be either drilled from solid to full size after assembling, or drilled small and reamed to full size after assembling. As most of the material is $\frac{13}{16}$ in. thick, or less, these specifications provided an opportunity to punch holes to the widest possible extent and yet insure the removal of all material possibly injured by the punching. All sheared edges of material more than ½ in. in thickness had to be planed off at least one-quarter of the thickness.

To insure perfect filling of holes, rivets with a grip less than four times their diameter had to have, when cold, a diameter not less than $\frac{3}{64}$ in. smaller than the finished hole where the holes were reamed or drilled after assembling, and not less than ⅛ in. smaller than the finished hole where the holes were punched full size (the latter occurred generally only in less important members). Rivets of a grip of four or more times the diameter had to be tapered to the same size and shape as those for the Hell Gate Bridge.*

Shop Assembling of Trusses.—The specifications prescribed that the connecting parts of the riveted trusses should be accurately laid out and assembled at the shop and that all rivet holes should be reamed or drilled in that position.

The complete assembling of the trusses or, at least, of a series of complete panels, would have assured the greatest accuracy and least chance for errors. This, however, was impracticable because, as previously explained, the angles

* *Transactions*, Am. Soc. C. E., Vol. LXXXII (1918), p. 920.

between the members had to conform to the "geometric" form of the truss, whereas the length of the members in their unstrained condition conformed to the "cambered" form of truss.

To assemble any panel or group of panels completely would have required forcible bending of the members and drilling of the holes in that condition, a very difficult and expensive operation. The trusses therefore were assembled in sections, as shown on Fig. 15, by connecting the web members to each chord separately. The members were carefully leveled and laid out with a transit to the correct angles, and the distances were carefully measured with a steel tape. The measurements were usually made in the early morning when the temperature was uniform in all parts.

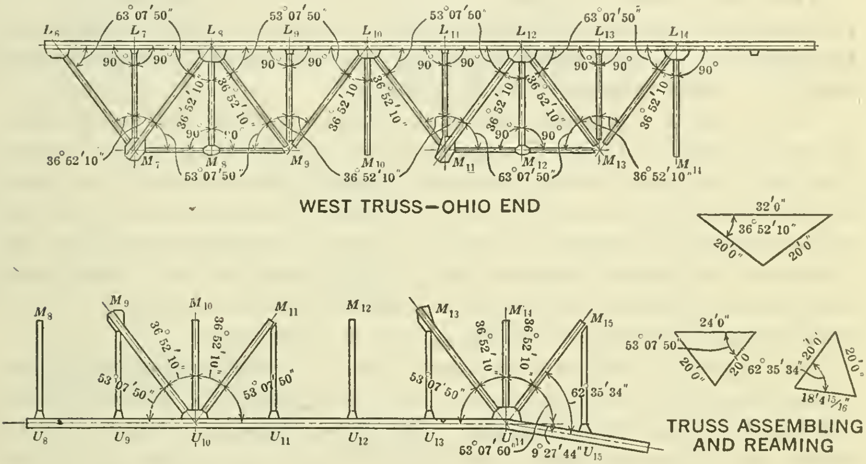


FIG. 15.

Connections were made with a sufficient number of $\frac{5}{8}$-in. tack-bolts to hold the members firmly together during the reaming and drilling of the holes. The holes for these bolts had been previously punched to $\frac{11}{16}$ in. in diameter, and all other holes were then drilled from the solid. For this purpose, all the holes in the top plate of each web, in the position in which the members were laid for assembling, had been previously punched to $\frac{11}{16}$ in., and this plate served as a template for drilling the holes. Finally, the holes which served for the tack-bolts, were reamed to full size.

The chords were laid first to an exact straight line, the joints being brought to perfect and forcible contact, and the reaming and drilling of the holes of the splices was started before the web members were assembled. The two halves of the main diagonals, having a splice at the M-points, were assembled to each other in the shop to a straight line, then taken apart and re-assembled to the chords in the assembling yard.

The sub-diagonals, hangers, and horizontal struts were first connected up and reamed at one end, then shifted slightly for connecting up and reaming of the other end. While one end of the sub-diagonals was being reamed, the

other end was held in position by a temporary connection through a few extra holes provided for that purpose, which later were plugged. Connections of sub-posts, which are of secondary importance, were allowed to be reamed to an iron templet. All connections were match-marked before the assembled sections were dismantled.

Erection.—A detailed description of the erection of the steel superstructure which offered many difficult and unprecedented problems, has been given in a series of articles* by Clyde B. Pyle, M. Am. Soc. C. E., Field Engineer for the McClintic-Marshall Company, the contractors for the fabrication and erection of the steelwork. Therefore, only the general procedure and the conditions and considerations which governed the method of erection, will be mentioned here.

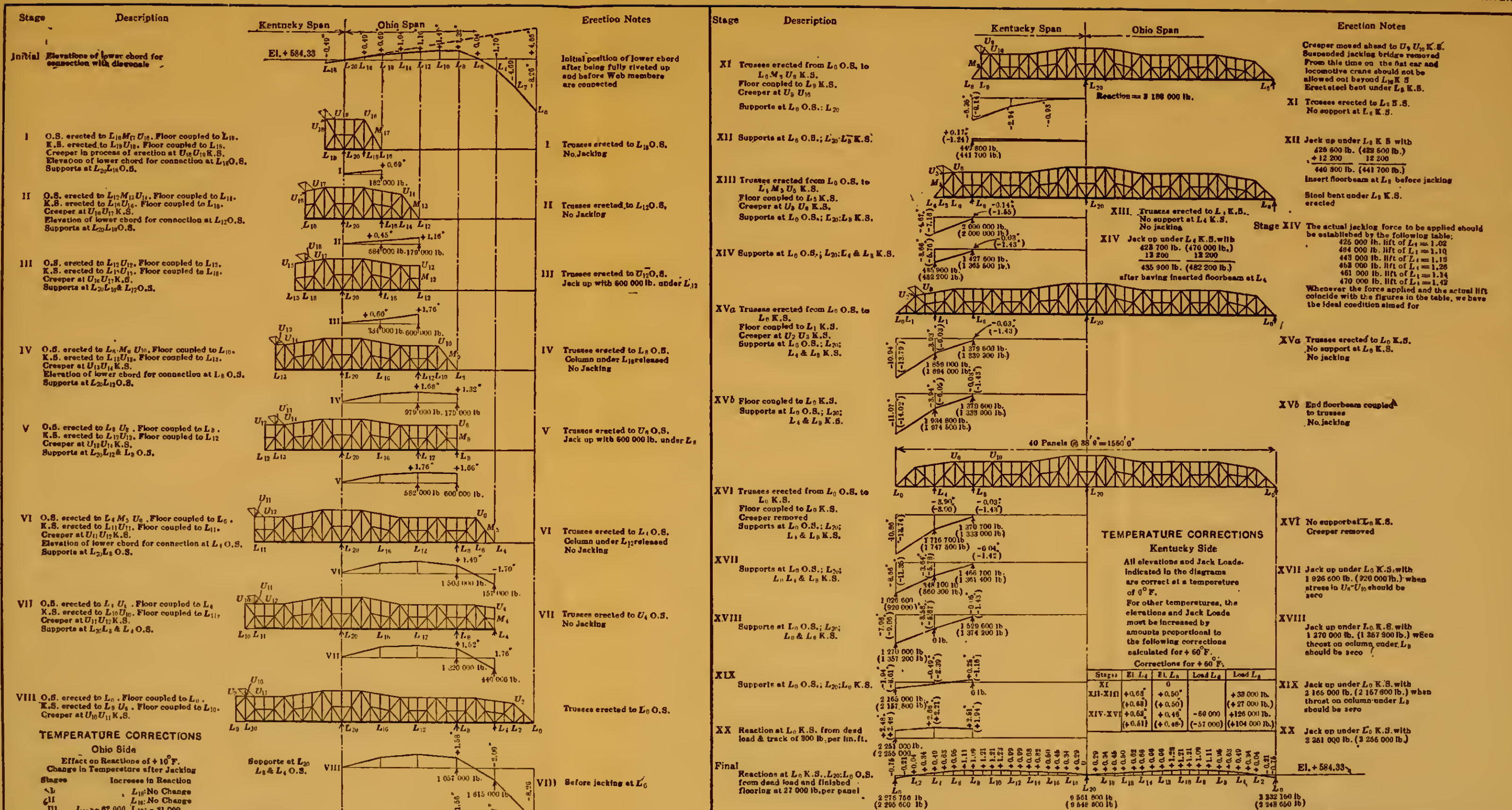
The War Department required the maintenance, during erection, of a minimum clear opening of 420 ft. over the river channel on the Kentucky side, for navigation. It was evident, therefore, that this part of the Kentucky span had to be erected by the cantilever method.

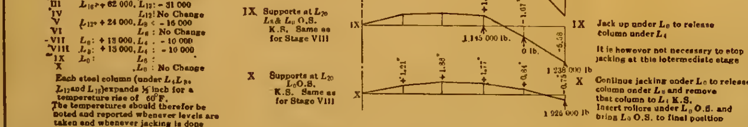
No opening for navigation was required under the Ohio span and this span lent itself better for falsework erection also on account of the shallow bottom. Even with that span, however, great risks had to be taken because of the danger of the falsework being carried away by a sudden flood, especially as no piles could be driven on account of the rock bottom. To minimize this danger the contractor used narrow falsework towers placed under the main panel points only, instead of closely spaced bents, thus leaving openings of about 60 ft. under the main portion of the span for the passage of drift and ice.

The erection of the entire Kentucky span as a cantilever, without intermediate support, would have required heavy additions to the chords and some web members near the middle pier. The plans, therefore, contemplated the erection of the four end panels near the Kentucky shore on falsework with two panels cantilevering beyond, and the other fourteen panels by cantilevering from the center pier. This scheme would have required only a comparatively small addition to some of the members. The six panels on the Kentucky side would have been erected simultaneously with the other portion, which would have saved considerable time. It would have required, however, a separate erection plant on the Kentucky side, and, moreover, the connection of the two joining arms would have presented difficulties. For these reasons, the contractor preferred to erect the entire span as cantilever from the center pier, giving, however, intermediate support by steel bents at the eighth and fourth panel points from the end pier, as soon as these points were reached. (Plate VI.) Thus, the free cantilever portion was reduced to twelve panels or 465 ft. Even so, it was the longest cantilever truss ever erected. The two falsework towers near the center pier on the Kentucky side were placed merely for convenience in erecting the extremely heavy panels near that pier by means of the gantry traveler, but did not assist in the cantilever erection of the remainder of the Kentucky span.

One of the principal features of the erection of this bridge was the initial bending of the members, which was necessary in order to reduce the secondary

* *Engineering News-Record*, January 10th and 31st and December 26th, 1918.





DEFLECTION CONSTANTS (Ky. Side)

	Deflection at L_0	Deflection at L_4	Deflection at L_8
Bridge erected to L_8, Traveler at U_9 U_{10}			-12.08 (-16.82)
Bridge erected to L_4, Traveler at U_5 U_6		-61.99 (-63.10)	-37.22 (-45.09)
Bridge erected to L_0, Traveler at U_2 U_3	-121.86 (-148.06)	-84.88 (-116.12)	-66.27 (-60.20)
100 000 lb. at L_0	5.17 (6.27)	3.90 (4.72)	2.62 (3.19)
100 000 lb. at L_4	3.90 (4.72)	3.06 (3.69)	2.08 (2.51)
100 000 lb. at L_8	2.63 (3.19)	2.08 (2.51)	1.52 (1.64)
Column Compression for a load of 100 000 lb.	0	0.0193	0.0193

DIAGRAMS SHOWING PRINCIPAL ERECTION STAGES. DEFLECTIONS AND JACKING OPERATIONS

NOTES:- All Reactions and Jacking Loads are given in Pounds for one Truss.
All Deflections are given in inches.
Figures in parentheses are computed on the basis of no allowance made for details as affecting the cross-sections of the members.
All other figures are computed on the basis of an addition to the cross-sections equivalent to 75% of the weight of the details of the members.
Figures of elevations denote the height above or below a horizontal line through the L_{20} point. (El. Base of Rail + 590.08.)
O. S. denotes Ohio Span. K. S. denotes Kentucky Span
Compare Mc Clintic Marshall Co.'s Drawings: D_1, D_2, D_3 & D_4

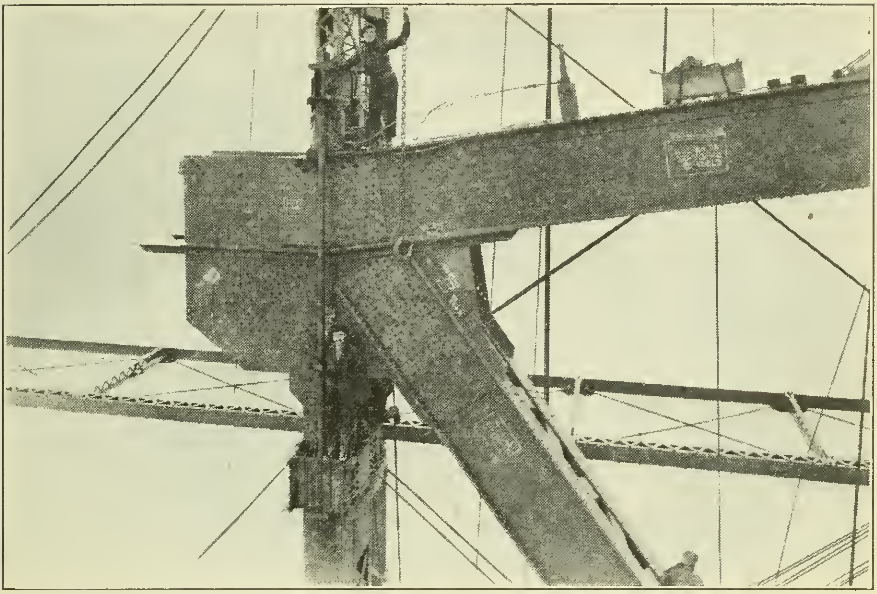


FIG. 16.—SPECIAL JACKING APPARATUS, SCIOTOVILLE BRIDGE.

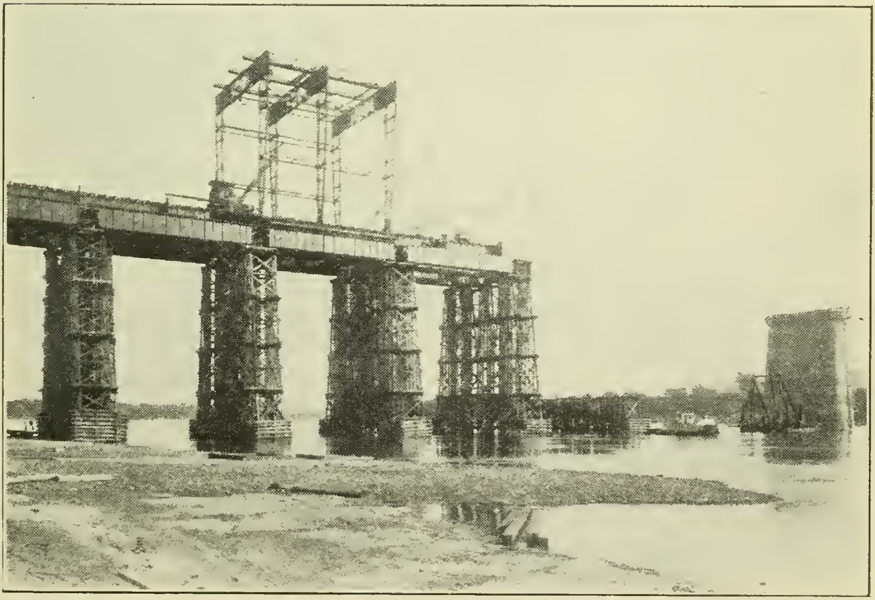


FIG. 17.—ERECTION OF FALSEWORK AND LAYING OF STEEL FLOOR SYSTEM AND TRACKS BY GANTRY TRAVELER, SCIOTOVILLE BRIDGE.

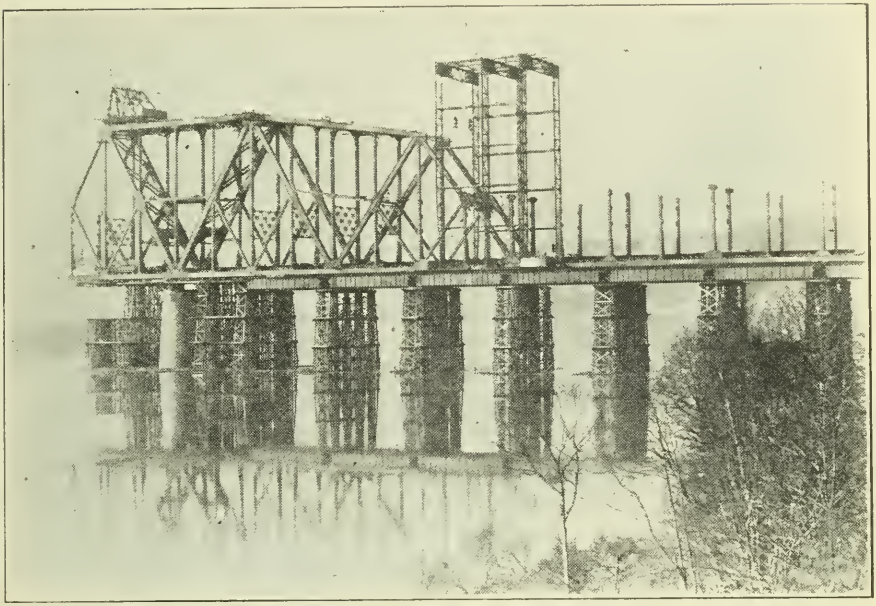


Fig. 18.—Erection of Trusses, Ohio Span, Sciotoville Bridge.

Fig. 19.—Erection of Ohio Span Completed, Sciotoville Bridge.

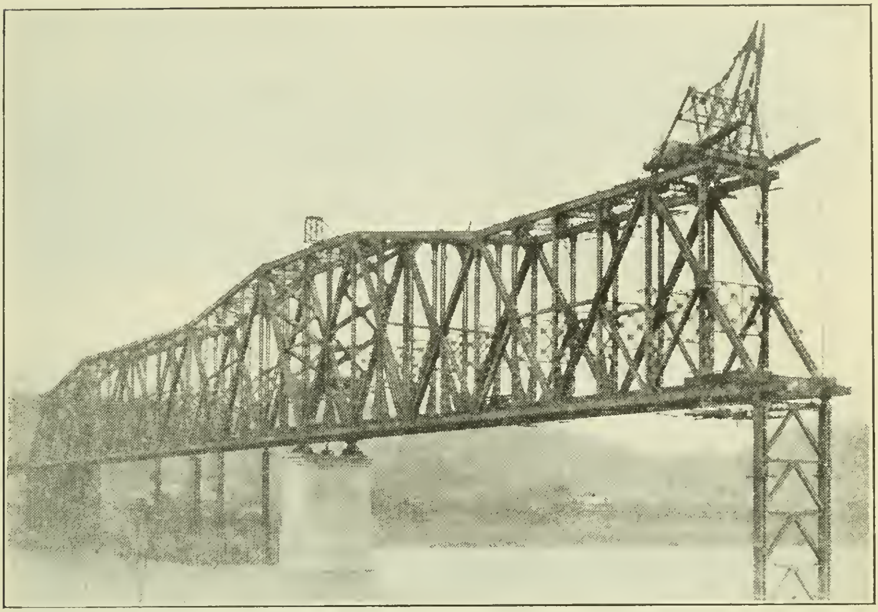


FIG. 20.—CANTILEVER ERECTION, KENTUCKY SPAN, AND FALSEWORK UNDER OHIO SPAN REMOVED, SCIOTOVILLE BRIDGE.

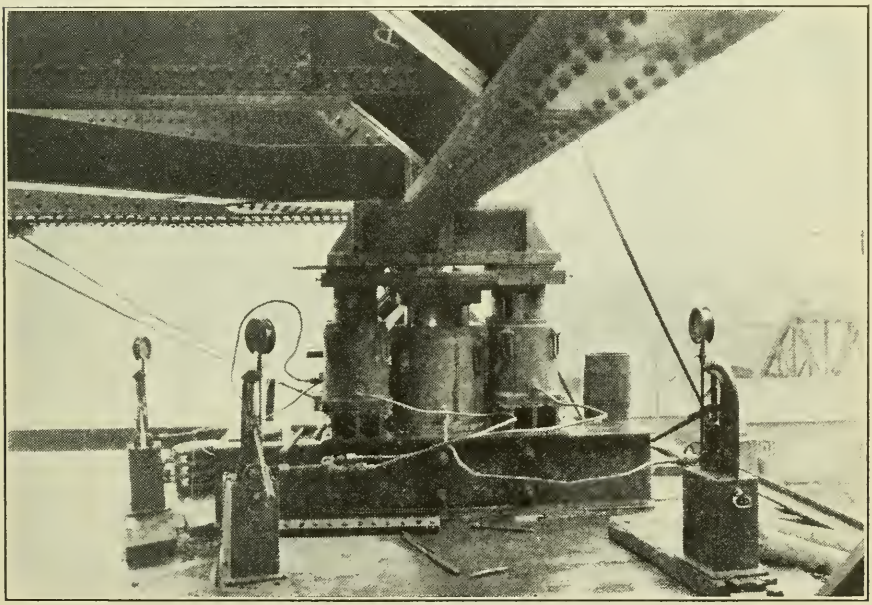


FIG. 21.—ADJUSTMENT OF KENTUCKY SPAN, SCIOTOVILLE BRIDGE, BY HYDRAULIC JACKS.

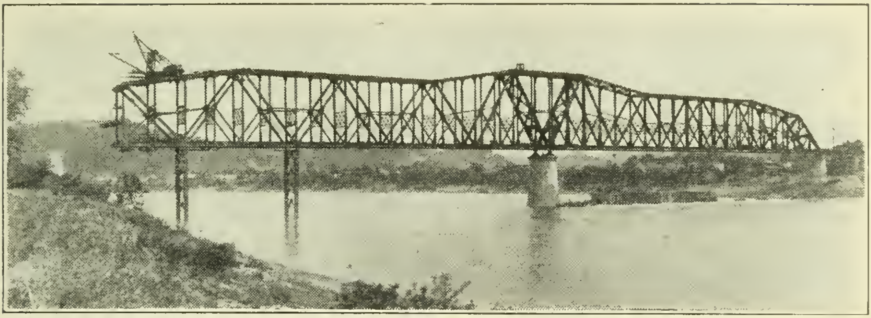


FIG. 22.—CANTILEVER SECTION, KENTUCKY SPAN, SCIOTOVILLE BRIDGE.

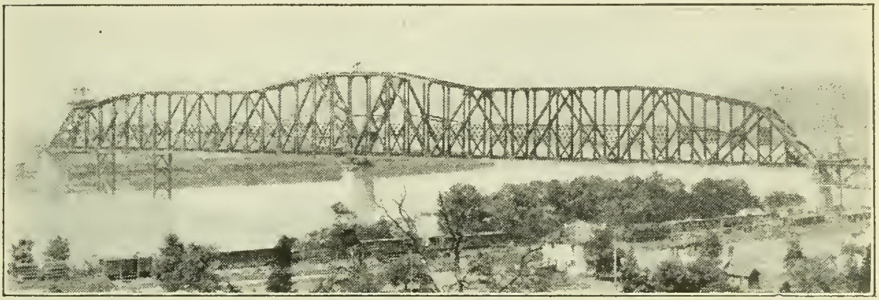


FIG. 23.—KENTUCKY SPAN, SCIOTOVILLE BRIDGE: TEMPORARY SUPPORTS READY FOR DISMANTLING.

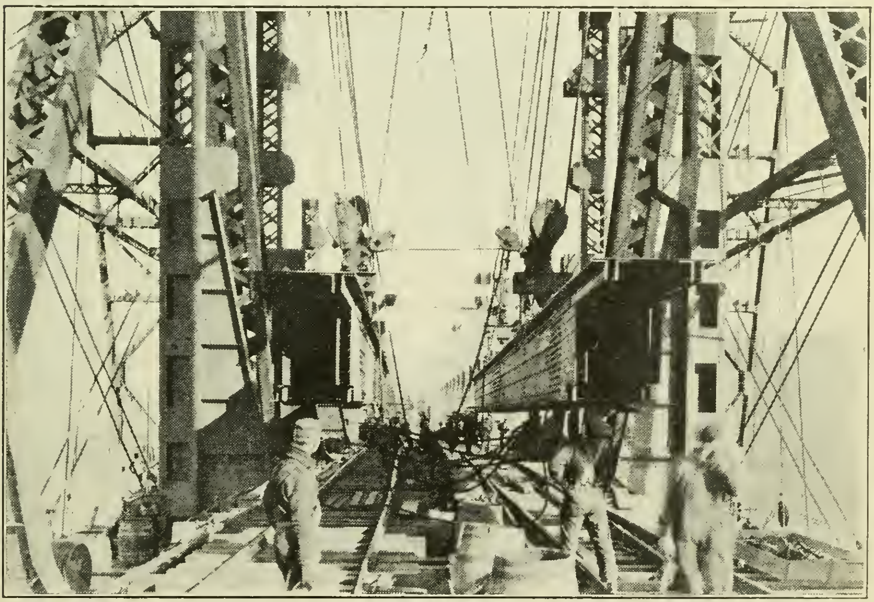


FIG. 24.—PAIR OF TOP CHORD MEMBERS, SCIOTOVILLE BRIDGE, BEING LIFTED SIMULTANEOUSLY.

stresses, as explained previously. These operations, as well as the adjustments in height of the trusses at the end piers and the temporary intermediate supports, required elaborate preparations and special jacking devices (Fig. 16) as fully described in the article by Mr. Pyle. The contractors deserve full credit for the careful and elaborate manner in which the operations were prepared and successfully executed.

In the main the erection procedure was as follows: By means of a gantry traveler, the falsework and on it the steel floor system and delivery tracks were laid from the pier on the Ohio shore to two panels beyond the center pier on the Kentucky side. (Fig. 17.) Then, working toward the pier on the Ohio shore, the traveler laid the bottom chords which were riveted at once while lying in a straight line and were then jacked to the desired camber. In this position, the Ohio end was 8¼ in. lower than its final position.

The traveler in the meantime having been raised to its full height and brought back to the center pier, the erection of the trusses was then proceeded with, working toward the Ohio end. (Fig. 18.) It had been intended originally to proceed simultaneously with the cantilever erection of the Kentucky span, but, on account of a shortage of labor and the approaching winter and high-water season, with its dangers to the falsework, all efforts were concentrated on the Ohio span in order to hasten its completion.

Consequently, the creeper traveler which, in the meantime, had been placed on top of the trusses over the center pier, had erected only one panel on the Kentucky side by the time the Ohio span was completely connected up (Fig. 19). The creeper traveler then proceeded with the cantilever erection of the Kentucky span and, at the same time, the timber falsework under the Ohio span was gradually removed, leaving only the steel columns under Panel Points 4, 8, 12, and 16 to support the trusses (Fig. 20). The releasing of these columns was finally accomplished by jacking the Ohio end of the span to its final position, when the Kentucky cantilever had reached about mid-span. The jacking was done by one 500-ton and four 200-ton hydraulic jacks under each truss (Fig. 21).

The Kentucky cantilever, having reached the eighth panel point from the end (Fig. 20), was jacked up 7⅜ in. from the steel bent erected at that point. This procedure was repeated when the truss reached the next bent at the fourth panel point from the end. The jacking height at that point was 1 in. (Fig. 22). When the truss reached the pier on the Kentucky shore (Fig. 23), it had a deflection of 16¼ in. It was then jacked up to its final position and placed on the rocker bearings, whereby the intermediate supports were released of their load. The final jacking force agreed so closely with calculated reactions that no further adjustment was necessary. Fig. 24 shows a pair of the top chord members being lifted simultaneously.

The operations described indicate sufficiently the sensitiveness of the structure from variations of deflections during erection and the necessity for their accurate analysis and computation in advance in order to insure an exact fit in the connections.

The erection of the steel work was started in June, 1916, and the bridge was completed in August, 1917. From the beginning of the work on the coffer-

dam for the middle pier in November, 1914, to the completion of the superstructure in August, 1917, in all 2 years and 10 months were required for the work which, under normal labor conditions, would have taken less than 2 years.

The writer was assisted in this unusual work, bristling with new problems and difficulties, by O. H. Ammann, M. Am. Soc. C. E., as Principal Assistant Engineer in general charge; D. B. Steinman, M. Am. Soc. C. E., on computations of superstructure; and W. A. Cuenot in the drafting and checking of detail plans. R. T. Robinson, Assoc. M. Am. Soc. C. E., acted as Resident Engineer, and R. E. McGough as Chief Inspector of Steelwork at the shops.

The foundations and masonry were satisfactorily executed by the Dravo Contracting Company of Pittsburgh. The steel superstructure was fabricated and erected by the McClintic-Marshall Company of Pittsburgh, under its Chief Engineer, the late Paul L. Wolfel, M. Am. Soc. C. E. The erection was in charge of E. A. Gibbs, Assoc. M. Am. Soc. C. E., General Manager for McClintic-Marshall Company, with Mr. Clyde B. Pyle as his Field Engineer.

The writer desires here especially to acknowledge the conscientious and painstaking labor of his assistants and the helpful experience of the contractors, who combined in the successful completion of the work.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

CORE STUDIES IN THE HYDRAULIC-FILL DAMS OF THE MIAMI CONSERVANCY DISTRICT

By Charles H. Paul,* M. Am. Soc. C. E.

Synopsis

Much has been written from time to time about the condition and behavior of core material in hydraulic-fill dams. A systematic study of the subject has been carried on during the construction of the five dams of the Miami Conservancy District, with the result that many of the doubts that have existed heretofore regarding the stability of hydraulic-fill cores, have been dispelled. It will be shown in this paper that:

1.—The gradation of core material may be controlled during construction, even with borrow-pit materials of widely different character.

2.—A considerable excess of fines is required in the borrow-pit material, in order to maintain proper control of the core and to prevent the encroachment of gravel and sand into the core zone.

3.—A reasonably wide core, namely, core width at any point equal to height of dam above that point, may be obtained with absolute safety.

4.—A fairly high percentage of extremely fine material in the core is not objectionable, provided the material is properly graded.

5.—Such cores show a satisfactory rate of consolidation.

6.—Such cores are stable, after a few months of consolidation, to the extent that they will not flow when the support of the outside slope material is removed.

The five hydraulic-fill dams of the Miami Conservancy District form retarding basins to control flood discharges in the Miami Valley, Ohio. Table 1 gives the maximum height, length, and volume of each of the Conservancy dams.

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Chf. Engr., Miami Conservancy Dist., Dayton, Ohio.

TABLE 1.—SIZE OF MIAMI CONSERVANCY HYDRAULIC-FILL DAMS.

	Germantown Dam.	Englewood Dam.	Lockington Dam.	Taylorsville Dam.	Huffman Dam.
Maximum height, in feet........	110	125	78	78	73
Length, in feet..................	1 200	4 700	6 400	3 000	3 300
Volume, in cubic yards.........	800 000	3 600 000	970 000	1 130 000	1 350 000

It will be noted that these dams vary in volume from 800 000 to 3 600 000 cu. yd. and in maximum height from 73 to 125 ft.

Fig. 1 shows the standard cross-section which was adopted for the Conservancy dams.

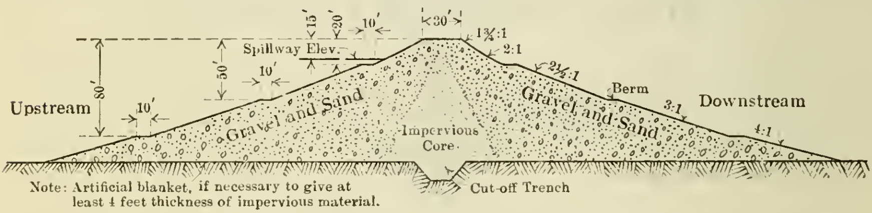

FIG. 1.

The construction of the dams was begun during the season of 1918, and all of them have now been completed. Two of them have already been in action during a flood flow in the river.

BORROW-PIT STUDIES LED TO HYDRAULIC-FILL CONSTRUCTION

Before the type of dams to be built in the Miami Valley was decided on, careful examination was made of foundation conditions and of materials available for construction. The foundation conditions dictated the selection of earth dams at all the sites, and borrow-pit investigations indicated that hydraulic-fill dams would be practicable and economical. The decision as to hydraulic-fill construction was not made, however, before consultation with several experts in that type of construction, and after careful mechanical analyses of the borrow-pit material to determine the relative quantities of coarse and fine, and especially the percentage and character of the material that would pass the 100-mesh sieve. These analyses, as well as precipitation tests, indicated that both in quantity and quality the fines in the borrow-pit material would meet the requirements of a good hydraulic-fill core. Further tests by the United States Bureau of Soils, at which better facilities are available than in the ordinary laboratory, including comparisons with similar material from other hydraulic-fill dams, confirmed the preliminary conclusions, namely, that the embankment material available was well suited to hydraulic-fill construction.

DESIGN OF CORE

Careful study was given to the design of the core for the Conservancy dams, with the result that the core width at any point was made equal to the

height of the dam above that point. This gave a core of such shape that sloughing of the outside slope material would not be encouraged, and of sufficient width so that, with reasonable care, the encroaching of sand and gravel too far into the core zone could be prevented, and narrow enough so that additional material to that required to give stable slopes would not be necessary in order to hold the pressure of the semi-liquid part of the core during construction.

In order to obtain cores of the dimensions decided on, it became necessary, at one of the dams, to waste a considerable quantity of the core material available in the borrow-pit, and, at two others, to open auxiliary pits in clay deposits on adjacent hillsides, to make up for deficiency of fines in the main borrow-pits. There are decided advantages in having a surplus of core material available, so that a part at least of the finest of that material may be wasted: First, a better gradation of core material may thus be obtained; in fact, after the selection of the borrow-pits, and such selection of material in the pit as is practicable as excavation proceeds, the wasting of fines affords about the only remaining opportunity to control the gradation of the core material; and, second, a more rapid consolidation of core results, by disposing of some of the extremely fine particles which, otherwise, are held in suspension for a long period, tend to lubricate the whole mass, and retard the process of consolidation by the holding up of particles which of themselves would settle more rapidly.

The Goldbeck Pressure Cell

In order to study the action of the hydraulic-fill cores during construction, it was determined to place at various elevations, in all the dams, a number of Goldbeck pressure cells. Preliminary experiments with these cells by the U. S. Bureau of Public Roads, at the writer's suggestion, indicated that they would give reasonably correct results if placed in hydraulic-fill cores. A full description of this apparatus, as well as a discussion of the experiments referred to, have been published.* Briefly, the Goldbeck cell (Fig. 2) is a closed, flat, circular box, $5\frac{1}{2}$ in. in diameter, similar in shape to a shoe-blacking box, the top or bottom of which acts as a movable diaphragm. It is operated by slowly admitting compressed air through a small pipe, to the inside of the box. The air is supplied from a small tank which may be charged with an ordinary tire pump. The cell is buried at a known elevation in the core, and the movable diaphragm is held down by the pressure of the material. When the pressure of the air on the inside equals the pressure of the material on the outside, the diaphragm is lifted slightly, an electric contact is broken, and an indicator light in the registering apparatus goes out. At that instant, the gauge on the air line indicates the pressure of the material against the movable diaphragm. The operation of the cell requires a movement of the diaphragm of less than 0.001 in. The cell may be set either horizontally or vertically, and, thus, either vertical or lateral pressure may be determined.

In addition to the Goldbeck cells, it was planned also to use the ordinary rod and ball tests, as construction proceeded.

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* *Engineering News-Record*, April 18th, 1918, p. 758.

Construction Methods

The embankment material was pumped into each of the Conservancy dams, by 15-in. dredge pumps, as it was impossible to sluice directly from the borrow-pit to the embankment. In two cases, however, the borrow-pit material was broken up by hydraulic giants and sluiced to sumps where it was picked up by the dredge pumps and pumped into place. At the other three dams, the borrow-pit material was excavated by drag-line machines, loaded into cars, hauled to the dams, and dumped into long shallow bins or hog boxes. At the hog boxes, hydraulic giants were used to wash the material to the dredge pumps. Thus, it will be seen that, by the time it reached its place in the dam, the borrow-pit material was thoroughly broken up and separated.

The discharge pipes laid down this material along the outer edge on either side of the dam section; a low levee or dike, along the outside slope, forced the discharge to flow toward the center where the core pool was maintained. The usual separation, characteristic of hydraulic-fill construction, was thus obtained. The coarser material, consisting of cobbles, gravel, and coarse sand, remained in the outer parts of the embankment, and the fine sand, clay, and silt, flowed to the center with the water, and settled through the core pool, to form the impervious core.

Distribution of Material in Dam Section

In every case, this general separation of material was obtained to the extent that the outside slope material was pervious, free draining, and composed largely of coarse particles, whereas the cores were impervious and of fine material. It should be noted, however, that the theoretical gradation of material outside the core zone, from coarse at the outside to fine toward the center, is hardly perceptible, except by careful examination, and then only in a general way. Although the material near the outside slope line contains a larger percentage of coarse particles and is more pervious than that near the edge of the core, still considerable coarse gravel is distributed through the section of the dam from the outside slope to the edge of the core, and there is considerable sand near the outside slope as well as near the core zone, which is of no importance. It is also true, however, that a considerable quantity of the fines is trapped in this outside slope material, which is of importance and must be taken into consideration in any analysis of borrow-pit material. Unless such analysis shows a large surplus of fines in addition to that required by the theoretical core section, it is almost certain that the necessity of an additional supply of core material will develop during construction. This happened at two of the Conservancy dams, and although it was not entirely unexpected at one of them, it had not been anticipated at the other.

At all five of the dams there was a distinct deposition of sand at the edge of the core pool, forming a definite separation between the slope material and the core material. The water flowing down the beaches from the discharge end of the dredge pipe, dropping the gravel and coarser material

TABLE 2.—MECHANICAL ANALYSES OF TYPICAL CORE SAMPLES.

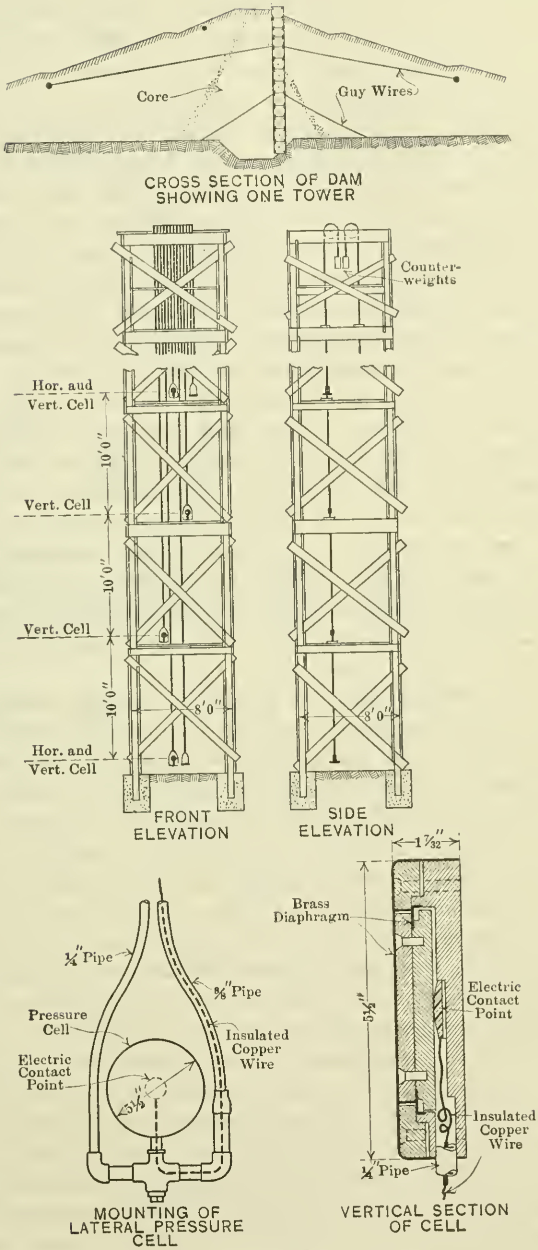
Bureau of Soils, standard sizing.	Germantown.			Englewood.					Lockington.				Taylorsville.						Huffman.				Average.
Percentage of fine gravel, 2 to 1 mm	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percentage of coarse sand, 1 to 0.05 mm........	0	0	0	0.4	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0.1	0	0	1.1	0.7	0.1
Percentage of medium sand, 0.5 to 0.25 mm.....	0.1	0	0	0.3	0.2	0	0	0.5	0.7	0	0	0.5	0.1	0	0	0	0	0.2	0	1.6	0.8	0.8	0.3
Percentage of fine sand, 0.25 to 0.10 mm............	1.5	4.2	2.1	4.6	1.6	3.6	0.5	2.6	8.6	1.0	1.5	3.1	1.9	0.5	2.0	0.4	0.1	3.5	2.8	13.7	2.9	6.2	3.0
Percentage of very fine sand, 0.10 to 0.05 mm.	14.0	17.3	21.2	19.6	16.8	19.3	12.4	5.4	12.6	10.1	33.2	39.0	18.1	19.7	13.9	2.3	4.2	24.6	15.0	25.4	31.4	23.0	18.2
Percentage of silt, 0.05 to 0.005 mm............	64.2	56.0	55.2	52.7	57.7	55.2	72.0	60.5	52.6	59.3	55.8	40.4	59.7	60.8	61.8	62.9	62.1	50.2	52.5	46.2	50.2	49.2	55.9
Percentage of clay, 0.005 to 0 mm............	20.3	22.5	21.5	22.6	23.9	22.0	15.2	31.0	24.8	29.3	9.5	16.9	20.2	19.1	22.3	34.3	33.7	21.4	29.8	12.9	13.7	20.4	22.2

along the way, carried still an appreciable quantity of coarse sand when it reached the core pool. Its velocity was checked as it entered the pool, and its burden of coarse sand was immediately dropped, only the finest of the material, that is, the fine sand, clay, and silt, going into the core zone where it settled slowly through the core pool. This, in general, was what happened when construction conditions were right. Irregularity in shore line, concentration of flow down the beach, deficiency of core material, and similar unfavorable conditions which continually occur on construction work, regardless of how well it is organized, occasionally resulted in tongues of the coarser material extending into the core zone, thus emphasizing the necessity of a reasonably wide core section to take care of such contingencies which, however undesirable, can hardly be eliminated. The matter of gravel and sand sloughing or raveling into the core will be discussed in detail later.

Core Tests

The limitation of fines in the core material of the Conservancy dams was largely a matter of judgment, based on the analysis of core materials available, preliminary tests made in co-operation with the U. S. Bureau of Public Roads, and analyses of cores secured from other hydraulic-fill dams. After construction was started, frequent analyses of the core materials were obtained through the co-operation of the U. S. Bureau of Soils, and the rates of consolidation were studied. Table 2 shows the results of some of the analyses of typical core material.

Although cores of quite different compositions from those given may show as good results, it may be said that all five of these dams have been completed without the least indication of trouble with any of the cores, with ample proof that consolidation has taken place in a thoroughly satisfactory manner, and that the water-tightness of the core, as shown by several tests, is all that could be desired. In the writer's opinion, the most striking fact revealed by a study of Table 2, is that, with proper care, cores remarkably similar in composition can be obtained from different borrow-pit materials, in different river valleys, at points from 10 to 50 miles apart. It is not claimed that the gradation shown by these analyses can not be improved, but the results obtained at the Conservancy dams indicate conclusively that cores of about the composition shown are eminently satisfactory from the standpoints of rate of consolidation, degree of consolidation, and water-tightness. To call to mind, again, the different conditions under which these cores were obtained, it may be stated that at Lockington and Englewood the borrow-pit material was used as it came, with only such control as could be secured by varying the depth of excavation, thus obtaining a greater or less proportion of the clay over-burden, or by such other selection of materials as could reasonably be made without unduly increasing the cost of excavation. At Germantown and Huffman, the main borrow-pits were deficient in fines, and auxiliary borrow-pits, yielding a high percentage of clay, had to be opened. At Taylorsville, there was a large surplus of fines in the borrow-pit, and a considerable percentage of the core material had to be wasted. In the latter case, there was the ever-present temptation to decrease the cost by holding a



Core
Guy Wires
CROSS SECTION OF DAM SHOWING ONE TOWER
Counter-weights
Hor. and Vert. Cell
10'0"
Vert. Cell
10'0"
Vert. Cell
10'0"
8'0"
8'0"
Hor. and Vert. Cell
FRONT ELEVATION
SIDE ELEVATION
1 7/32"
Brass Diaphragm
Electric Contact Point
5½"
Insulated Copper Wire
¼" Pipe
¼" Pipe
⅜" Pipe
Pressure Cell
Insulated Copper Wire
Electric Contact Point
MOUNTING OF LATERAL PRESSURE CELL
VERTICAL SECTION OF CELL

FIG. 2.

large percentage of fines, and taking chances on a wider core than that called for by the design. In the other case, one had to reckon with the desire to narrow the core to fit the borrow-pit conditions. Perhaps both these modifications might have been made, within reasonable limits, without detriment to the work. In the light of present knowledge, however, it is believed that either would have been undesirable, and might have led to trouble.

Pressure Cell Tests.—About fifty of the Goldbeck pressure cells were placed in the cores of these five dams. Some have given satisfactory readings, and some have not. In cases where the readings look unreasonable, or where the cells fail to register, it is sometimes difficult to determine whether the trouble is in the cell or is due to faulty installation. With a few exceptions, there is no evidence that any of the unsatisfactory results have been due to fault in the cell itself. Defective installation is known to have been the cause of many of the unsatisfactory readings, and improvements in installation have resulted in marked improvements in results. This was a pioneer effort, and, naturally, much was to be learned by experience, before proper methods were determined for meeting the requirements, particularly as to the best methods of installation. The first installation was made at the Germantown Dam, as shown in Fig. 2. At this dam, the cells were suspended, by two ¼-in. pipes, from the top of a framed tower which was built in sections as the construction proceeded. Two pipes were necessary at these installations, one to carry the wire connecting with the registering apparatus and to take the charge of compressed air, and the other to be used as a blow-off in case water entered the pipe or the cell. This method of installation, however, was improved later. (Fig. 5.)

Cells were set in a vertical position (to measure lateral pressures) at 10-ft. vertical intervals, and in horizontal position (to measure vertical pressures) at 30-ft. vertical intervals. As the tower was raised in height, the pipes were extended by connecting another section at the top, and another length of wire (bell cord) was spliced on and threaded through the one pipe. The tower, surrounded by the soft core, was guyed at intervals to hold it in place.

In taking the readings, a portable gauge box, Fig. 3, was taken out to the tower, and connected to one of the pipes from which the cell to be tested was suspended, the pipe being connected to the pressure tank and the wire to the indicator light. A plug was removed from the end of the other pipe and a light "shot" of compressed air was admitted to the first pipe to displace any water which might have accumulated. It was only necessary to force this water out of the way so as to admit air to the cell, since the weight of a water column (if any) in the second pipe would register on the pressure gauge, and, therefore, would not affect the correctness of the reading; as a matter of fact, little trouble with water was encountered. The plug was then replaced in the end of the second pipe, and the compressed air was admitted slowly to the cell, until the movement of the diaphragm broke contact and put out the light in the gauge box. At that instant, the pressure gauge indicated the core pressure on the diaphragm. The movement of the diaphragm necessary to break contact (about 0.0001 in.) is so slight that the light may be put out and lighted repeatedly, by proper manipulation of the feed and exhaust valves,

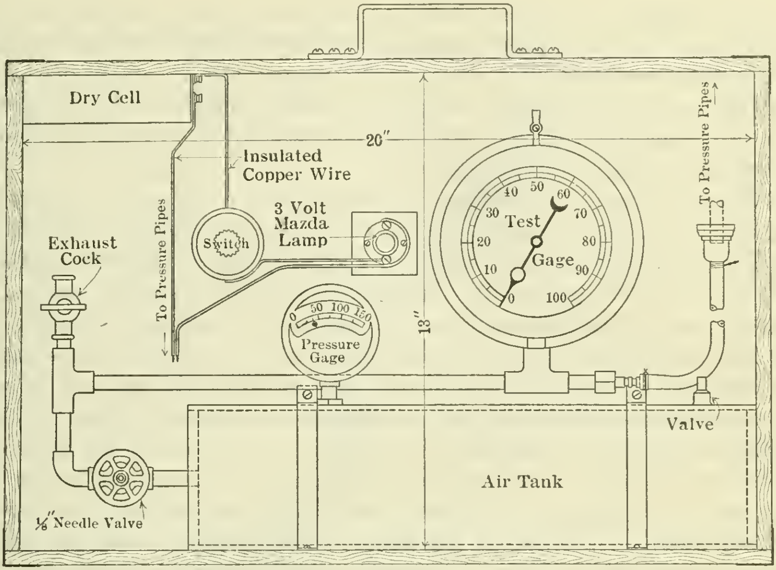


Fig. 3.

without changing the reading of the pressure gauge, thus showing that the slight movement of the diaphragm does not disturb the core.

A series of readings at Germantown, covering the period from September 10th, 1919, to May 20th, 1920, are shown on Fig. 4.

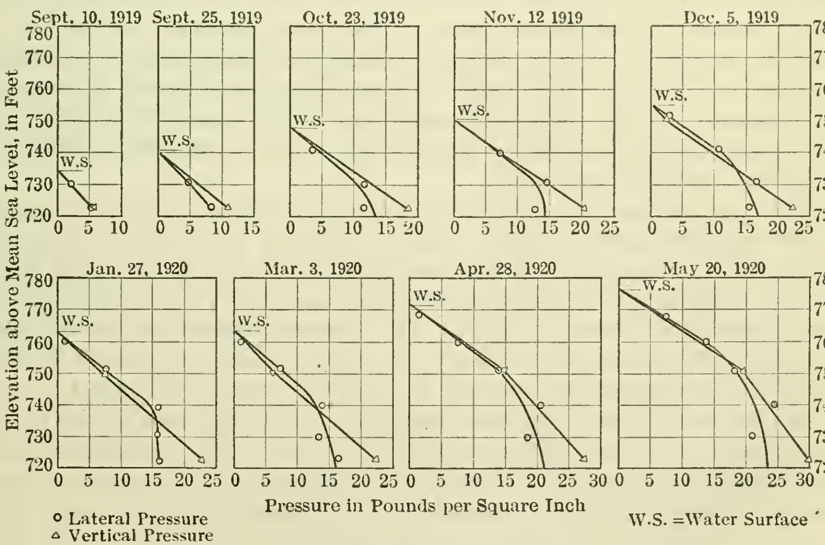


Fig. 4.

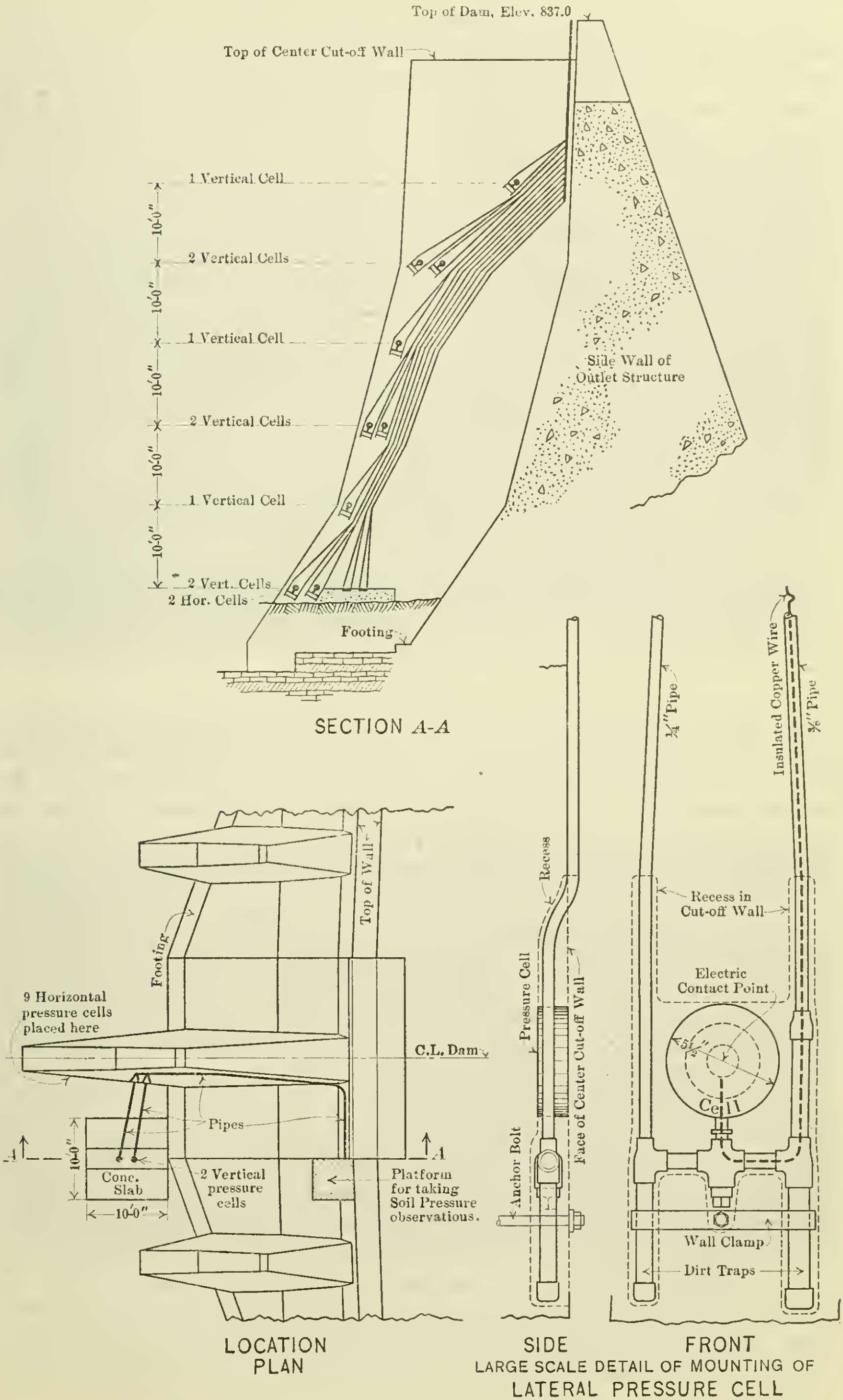
These tests show that after a few weeks the core material begins to consolidate (as indicated by the fact that the lateral pressures are noticeably less than the vertical pressures at the same elevations) and that as time goes

on the difference becomes greater, until after a few months the lateral pressures in the lower parts of the core are only about two-thirds to one-half the vertical pressures. In the writer's opinion this is conclusive evidence that the core at those points is losing its fluid properties and that consolidation is taking place. These conclusions are confirmed by later examinations of exposed cores, as will be mentioned.

These nine series of readings at Germantown, covering a period of eight months, were very satisfactory. Then things began to happen. The dam had reached a height of from 60 to 70 ft. and was being constructed at the rate of about 6 or 8 ft. per month. It became impossible to obtain further readings on some of the lower cells because air could no longer be forced through the pipe to the cell. This plugging of the pipe was due, in some cases, to the bunching of the insulation on the wire or at the splices, and, in others, to an accumulated deposit of dirt and flakes of galvanizing. When the length of this small pipe is considered (70 to 80 ft. in the case of the lower cells), this latter trouble is not surprising, although it was overlooked at the start. The use of larger pipe, more careful cleaning of the inside of the pipe, and the construction of a trap at the bottom of the pipe to catch the dirt, corrected these troubles in later installations. Some of the pipe joints then began to leak air, and, about that time, the upper part of the tower showed signs of distress, due probably to movement in the upper (partly fluid) portion of the core or to the settlement of material on the guys. This movement of the partly consolidated portion of the core was demonstrated by sinking a cast-iron ball into it, marking its position by a buoy, and checking that position from time to time. This simple test gave positive evidence that, in the earlier stages of consolidation, there is often some movement, or surging, of the semi-fluid core. Such movement, in itself, is of little consequence, except that it must be given consideration in cases where it is desired to construct a permanent tower or shaft within the limits of the core. Difficulties with such towers or shafts have been experienced in other hydraulic-fill dams, due no doubt to this core movement.

Thus, the pressure-cell tests at Germantown, following the period covered by the readings shown in Fig. 4, were of interest, principally in revealing defects to be corrected in future installations. The Englewood and Lockington installations were too far along to be corrected by the time the Germantown troubles had been analyzed. The readings obtained at these places confirmed the conclusions reached from the Germantown tests, but little additional information was secured, beyond what is shown in Fig. 4.

At Taylorsville, full advantage was taken of the experience gained at the other dams, and a much better installation was made. In this case, the cells were fastened to the side of a concrete cut-off, on the back of a high retarding wall forming a part of the outlet structure. Larger pipes were used, which were fastened securely to the same wall, and instead of joining up the pipe in sections as the dam was raised, the complete installation was made at the start. At the pipe joints special care was taken to secure a permanently air-tight joint. Dirt traps were provided at the bottom of all the pipes. (Fig. 5.)



Top of Dam, Elev. 837.0
Top of Center Cut-off Wall
1 Vertical Cell
2 Vertical Cells
1 Vertical Cell
2 Vertical Cells
1 Vertical Cell
2 Vert. Cells
2 Hor. Cells
10'-0"
10'-0"
10'-0"
10'-0"
10'-0"
Side Wall of Outlet Structure
Footing
SECTION A-A
Footing
Top of Wall
9 Horizontal pressure cells placed here
C.L. Dam
Pipes
10'-0"
Conc. Slab
10'-0"
A
A
2 Vertical pressure cells
Platform for taking Soil Pressure observations.
LOCATION PLAN
Recess
Pressure Cell
Face of Center Cut-off Wall
Anchor Bolt
¼" Pipe
Insulated Copper Wire
⅜" Pipe
Recess in Cut-off Wall
Electric Contact Point
5½"
Cell
Wall Clamp
Dirt Traps
SIDE
FRONT
LARGE SCALE DETAIL OF MOUNTING OF LATERAL PRESSURE CELL

Fig. 5.

Cells in vertical position, to measure lateral pressures, were set at 10-ft. vertical intervals as before, but in this case two cells were set at the bottom and at the 20-ft. intervals, in order to check the readings of one against the other, at those points. Cells to measure the vertical pressures were set at the bottom only, because of the difficulties of making a secure installation in horizontal position at the higher elevations, except at points where the vertical pressure would be affected by friction against the wall. Fig. 6 gives the results of readings at Taylorsville.

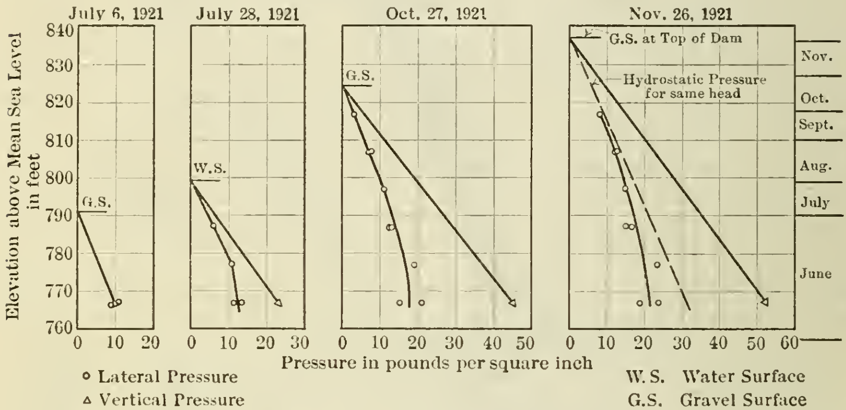


FIG. 6.

It will be noted that the two cells at the 20-ft., vertical intervals check each other very closely, except at the bottom, where consolidation has taken place to the extent that the lateral pressures are only about 40% of the vertical pressures. This is an indication that the pressure-cell readings are fairly reliable. It might be expected that when consolidation has reached the point where the core is practically a solid, actual lateral pressure might vary at different points to the extent indicated by the readings on the lower cells. The last set of readings (November 26th) were taken after the completion of the dam to its full height. The section of the dam in which the cells were set, was built up from Elevation 767, where the lowest cells are located, to Elevation 837, the top of the dam, during a period of six months; during one month the core was raised 33 ft. The monthly progress of construction of that section is shown on Fig. 6.

The Taylorsville method of installation is apparently satisfactory. The results to date have every indication of being reliable; they check with the readings at Germantown, as shown in Fig. 4, and they appear reasonable in the light of examinations of the cores in place, discussion of which will follow. The readings at Taylorsville will be continued for several months, or as long as any further information can be secured from them.

It is evident, from the data secured thus far, that properly graded core material need not be treated as a perfect fluid even after a few weeks of settlement, and that after it has been in place for a few months, the lateral pressure is only about 50% or less, of the vertical pressure at the same depth. It is

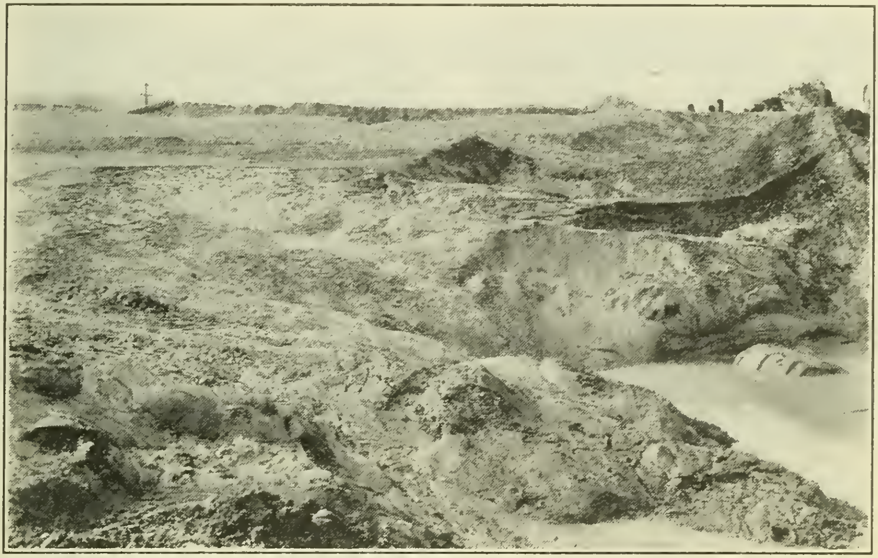


FIG. 7.—CORE OF HUFFMAN DAM, MIAMI CONSERVANCY DISTRICT.

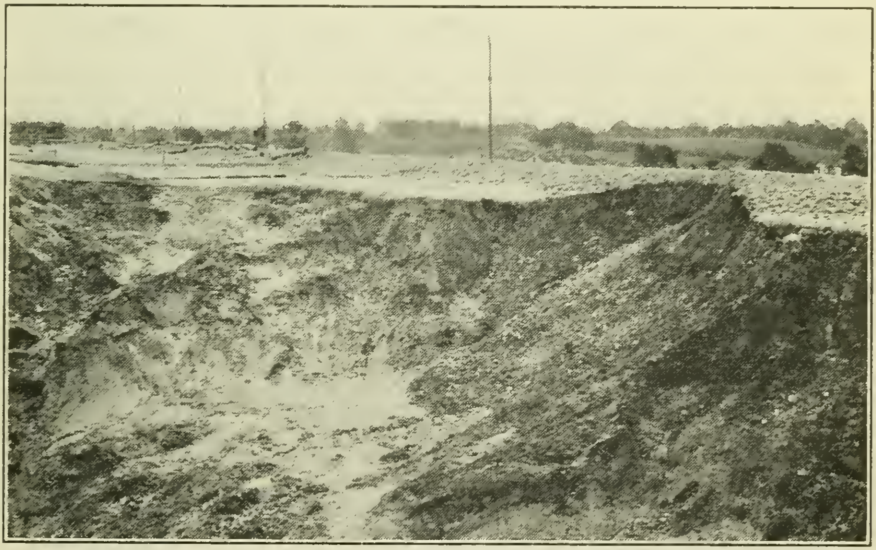


FIG. 8.—CORE OF LOCKINGTON DAM, MIAMI CONSERVANCY DISTRICT.

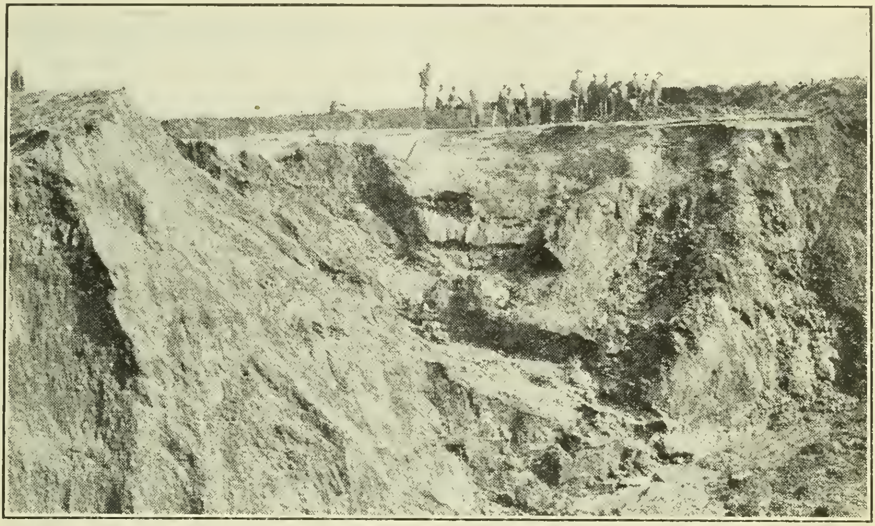


Fig. 9.—Core of Englewood Dam, Miami Conservancy District.

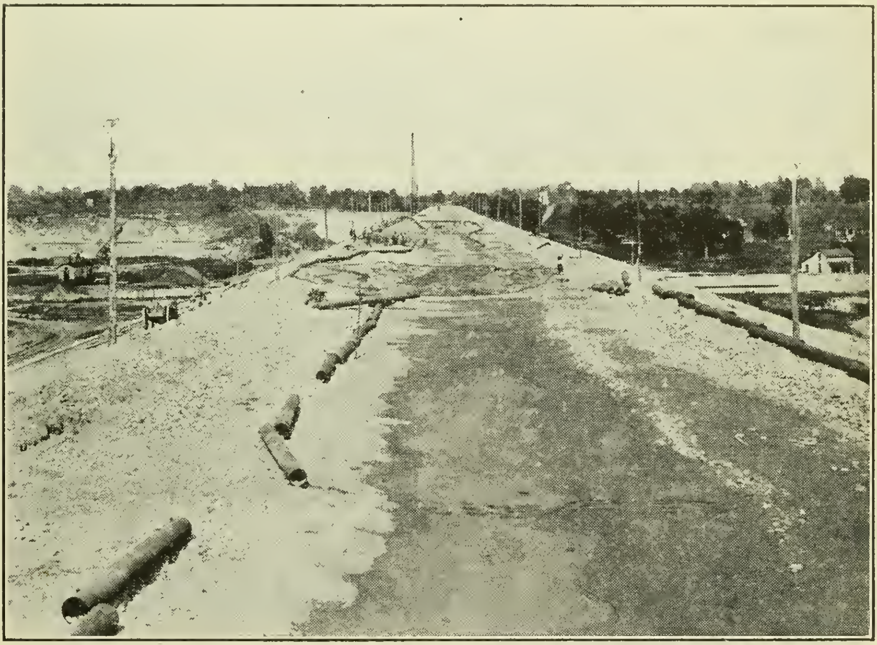


Fig. 10.—Top of Lockington Dam After Washout Due to Overflow of Core Pool.

believed that this may be accepted as a fact, to be kept in mind in the future design of hydraulic-fill dams.

Ball and Rod Tests.—Penetration tests with a 6-in. cast-iron ball, and with iron rods, were made at all the dams as the work progressed. These tests have been already described,* and as they are not of great importance, the discussion will not be repeated here. They indicated satisfactory and progressive consolidation of the core in all cases. Rod tests are of value in detecting the presence of gravel in the core.

Actual Core Examinations.—By far the most satisfactory and conclusive information as to the character of the cores of the Conservancy dams, has been obtained at three of the dams, by examination of the cores where they have been exposed in their undisturbed condition. At the Huffman Dam, the old line of the Erie Railroad passed through the dam site. The construction of the dam was started while the railroad was being re-located and in order not to delay this construction, a cross-dam was built along the edge of the railroad right of way, which held back the hydraulic core until after the tracks were moved. The core pool was then drained, the preparation of the foundation was made across the railroad right of way, and the cross-dam through the core section was removed, exposing the end of the core to a depth of 26 ft. Fig. 7 shows the core thus exposed.

Although 16 ft. of water stood against the exposed face of the core, and although it stood unsupported to a height of about 10 ft. above the water surface, little difficulty was experienced in cleaning the foundation for the new section of the dam and excavating the continuation of the cut-off trench. The texture of the core in the steep face, and how the bucket load of core, dumped by the drag-line machine, retains its shape may be noted in Fig. 7. The oldest of the core visible in this photograph had been in place about five months, and the top of it had been placed about two weeks before the photograph was taken. It would bear the weight of a man walking across it, after the core pool had been drained. The composition of this core material is represented by the Huffman analysis in Table 2. When studying this photograph, it should be kept in mind that the face of the core, below the water surface, was undercut by the excavation for the removal of the cross-dam and the continuation of the cut-off trench, which explains the slumping near the face.

At the Lockington Dam, when construction had been carried to within about 12 ft. of the top, the core pool overflowed, washing a gully in the up-stream slope of the dam and exposing the core to a depth of about 30 ft. from the top. A similar accident occurred at Englewood, at about the same stage of completion.† In each case, all the water in the core pool drained through the break. At Englewood, the quantity of water drained was estimated at not less than 800 000 gal. In both cases, the core stood up with almost vertical faces and none of it washed out, except just at the break. Only about 10% of the material moved by the wash-out was core material. Figs. 8 and 9 show the conditions at these dams immediately after the wash-outs occurred.

* *Transactions,* Am. Soc. C. E., Vol. LXXXIII (1919–20), pp. 1797, 1799, and 1800.

† *Engineering News-Record,* November 3d, 1921, p. 744.

It will be noticed in both photographs that the core stands up, unsupported, in almost vertical faces, and that there was no slumping of the core, except just at the wash-out. It is significant also, that there was little or no erosion of the core back from the break on either side, although a large quantity of water flowed over it when the wash-out occurred. (Fig. 10.) Nor was there any appreciable sloughing of the core during the three or four weeks that it stood unsupported while the wash-outs were being repaired. At Englewood (Fig. 9), the top of the core had been in place for less than two weeks before the wash-out. The oldest of the core in sight in the photograph had been in place only about twelve weeks.

Samples of the core material from these places were taken in both cases. At Lockington, five samples were taken at different places, after digging into the exposed face far enough to reach material that had not been disturbed or affected by the wash-out. Each of the samples was secured by using a 7-in. length of stove pipe, biscuit-cutter fashion, and immediately soldering on a top and a bottom, thus forming an hermetically sealed can, full of core as it lay in the dam. The moisture content of these five samples, as determined by the Bureau of Soils, varied from 21.8 to 22.6% by weight. The mechanical analysis averaged, as follows:

1-0.5 mm.	0.5-0.25 mm.	0.25-0.10 mm.	0.10-0.05 mm.	0.05-0.005 mm.	0.005-0 mm.
0	2%	6%	15%	55%	21%

which agrees well with the typical analysis of the Lockington core samples, given in Table 2. The low moisture content shows that the core gives up its surplus water within a comparatively short time; there is no doubt of that after an examination of the exposed core in place. Similar samples taken at Englewood had a moisture content of about 24 per cent. The weight per cubic foot was about 121 lb. A large number of pieces of core material at Englewood, some of which were 1 cu. yd. or more in size, were found at the foot of the slope after the wash-out, which showed the toughness of the core material. The Englewood wash-out occurred in a section of the dam that had been built up as much as 30 ft. vertically in 1 month, so it is evident that consolidation takes place rapidly, even when construction progress is fast. In the face of the evidence offered by these core exposures, there is no doubt that consolidation of these cores has progressed at a highly satisfactory rate.

How the Core Gives Up Its Surplus Water

There is difference of opinion as to how the surplus water escapes from the core. Experience at the Conservancy dams indicates that this process is more rapid than could occur by ordinary filtration action. It is very likely that some of the water drains out laterally, but there are indications that the greater quantity is displaced and forced up, vertically, by settlement of the solids and by pressure due to the superimposed material. In many places, where pumping had been discontinued temporarily, innumerable little springs might be seen in the bottom of the core pool, where water was being forced up by piping. Fig. 11 is an illustration of this at one of the dams, where the core pool had been drained preparatory to topping the dam.

FIG. 11.—CORE SPRINGS OF LOCKINGTON DAM, SHOWING HOW SURPLUS WATER IS FORCED UP THROUGH CORE.

There is further evidence that comparatively little of the water in the core material escapes laterally. While the dams were being built, seepage water was always in evidence at the toe of the porous slopes. This flow was greatly diminished at times when the dredge pumps were shut down and the level of the core pool had dropped 1 or 2 ft. During the construction of hydraulic-fill dams in the arid West, vegetation will grow at the foot of the slopes while hydraulic fill is in progress, but as soon as the work is discontinued, the vegetation will die for lack of water, the explanation being that along the edge of the core pool, immediately below the surface, is a strip of porous slope material not yet silted up by the core; as soon as the water surface drops below this unsilted material, little water escapes through the slopes, and the core pool holds the remainder of the water for a long time. The little springs are still in action, however, and the consolidation of the core goes on, forcing the surplus water to the surface, as illustrated in Fig. 11. It is difficult to explain the rapid consolidation of the Conservancy cores in any other way.

Gravel and Sand Sloughing into Core

Once at Huffman and several times at Englewood, trouble was experienced by the gravel and sand sloughing or raveling into the core, its presence being detected by the rod soundings. In every case, this happened when the core material was not brought up fast enough to correspond with the building up of the outside slope material, and it could always be prevented by keeping the core well filled with mud. The coarser material takes a fairly steep slope next the core pool, and each layer overhangs the one below. Water pressure is not sufficient to hold it in place. If the core pool is kept well filled with mud, however, it consolidates fast enough to keep the coarse material from sloughing in, and, here again, the advantage is apparent of having a surplus of fines in the core material so that some of the finest may be wasted.

A concentrated flow down the beach from the dredge pipe will tend to carry a tongue of gravel and sand out into the core. This may be prevented by shear boards to break up the concentration of flow, or by a floating timber held in by ropes close to the shore of the core pool, at the point where the flow enters the pool. By building up the dam in lifts of not more than 2 or 3 ft. at a time, this trouble may be avoided more easily.

Progress of Construction

It may be of interest to give a general idea of the rate of progress on the Conservancy dams. At Germantown, with one drag-line machine in the borrow-pit, and one dredge pump, an average month's work was about 60 000 to 70 000 cu. yd., and during one month, the output reached 91 500 cu. yd. At Huffman, with similar equipment, the rate of progress was about the same, although at Lockington, the progress was somewhat less. At Taylorsville, with four giants in the borrow-pits and two dredge pumps, the highest monthly estimate was 107 000 cu. yd. At Englewood, with three drag-line machines in the borrow-pit, and two dredge pumps, the quantity of material placed in the dam often reached 150 000 cu. yd. per month, and during one month it was 180 000 cu. yd.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

THE NATIONAL HOUSING PROBLEM*

A SYMPOSIUM

By Messrs. Charles Wellford Leavitt, Andrew J. Thomas, Morris Knowles, and Ernest P. Goodrich.

With Discussion by D. L. Turner, F. W. Look, William T. Lyle, and William H. Ham.

* Presented at the meetings of January 4th and 5th, 1922, and continued from February, 1922, *Proceedings*.

PROPERTY IMPROVEMENT AND LANDSCAPING

By Charles Wellford Leavitt,* M. Am. Soc. C. E.

The question of the subdivision of land within city limits after a city layout has been established, becomes one dependent on the desires of those who wish to purchase such land, and on the absorbing power of the purchasers. The inrush for higher pay, to cities constructed for manufactures, drew people from many of the rural districts, and congestion has been brought about thereby. These people will go back gradually to the rural districts where they will work the land and use the habitations. They have started in great numbers, already, in some parts of the environs of the largest cities; for instance, in the County of Westchester and in the County of Queens, New York State, there is a great deal of building going on at the present time, much of which is on small lots.

The people seem to desire less ground than prior to the World War. Before the war started, some far-seeing people realized that the workingman would leave the city and would demand a piece of land on which he could build a house and obtain the benefits of the country for his children. In one case, described later, a large tract of land was secured in the vicinity of Wilmington, Del., by a philanthropic gentleman. Much of the land in this vicinity is owned in extensive acreages by the powder interests. The whole tract, of about 5 000 acres near the city, was purchased with the intention of giving the workingman a medium sized lot, perhaps 80 ft. by 100 ft., or possibly less, just large enough for a house, and of locating that lot in such a position that the man and his family would have access to park lands laid out in long strips throughout the entire tract.

The land was acquired in a most unique way, the purchaser stating to the owners that eventually he was going to buy the land; whether he could do so this year, five years from now, or leave it to be done by others in fifty or one hundred years, it would be taken over, and they could sell it any time they pleased. In order to have it financed properly, he created a company, holding land that yielded a large income. The reaction of the owners to the proposition was such that they have given over their lands to the company at reasonable prices.

The second great movement, resultant from post-war conditions, is by people of ample means, who wish to live near the city and enjoy all the facilities that the city affords. They are buying lots of minimum dimensions within motoring distance of the city. They do not care to go farther; in other words, as they term it around Philadelphia, they wish to be in "the movie zone". The district lying between 25 and 35 min. of motor travel from the theater district in Philadelphia contains the highest priced property in that part of the country; a district lying 40 min. out demands almost one-half less. Apparently, 25 min., or so, from the theaters is all that is desired. The same thing pertains to districts near New York City, but to an even more limited

* Civ. and Landscape Engr., New York City.

extent, because the difficulties are much greater of getting back and forth from such a traffic-laden city as New York.

Several illustrations may be cited with regard to the so-called "diagonals" so much discussed. In certain places they seem neither advisable nor necessary.

On Lake Winnipeg, in Canada, lies Grand Marie, a peninsula of the lake, much divided into small peninsulas. The focal point is about in the middle of the largest part. From that, there radiate three distinct tracts of land, with water between the tracts, so that this city which has its head on a promontory projecting into the lake, maintains its street systems, which follow the tracts of land, in three different directions, forming naturally a set of diagonals. The ordinary diagonal of the city therefore is eliminated.

A similar condition was found in Kitchener (formerly Berlin), Ont., Canada. The city had been started by several additions which were projected at angles to each other, because the city was traversed by two ravines. There, again, it was practically unnecessary for diagonals.

A few years ago, Long Beach, on Long Island (Fig. 1), was a sand-bar, which, for about 4 000 ft., was taken over by a company and subdivided. The Atlantic Ocean is its southern boundary, and there is a channel in the rear. The railroad has been brought across the channel and is to be extended through the center of the city. There was no particular need for diagonals in this layout. The lot unit, as planned, was 20 ft. by 100 ft., and lots were sold in groups of three. The traffic is largely east and west, so that the east and west streets were placed about 200 ft. apart, and the north and south streets about 700 ft. apart.

In prognosticating traffic, one realizes that if, in the beginning, such a system for New York City had been laid out the present congestion would not exist. Although a diagonal between the Pennsylvania Station and the Grand Central Terminal would be a great help, it would not relieve the situation entirely. It might alleviate it temporarily, but the only solution of the delays in traffic occurring in New York City to-day is the construction of north and south thoroughfares. However, a diagonal is a feature to be respected and not rejected entirely for all cases, although it has been introduced in many places where it was not always necessary, and, at the best, it is a destructive street which becomes extremely dangerous with heavy traffic.

Another large tract of land, which was planned twenty-four years ago and which gradually has been filling up with intensive population, is Garden City, on Long Island, where there existed about 8 000 acres in one tract, a part of which was taken for the subdivision. This tract was traversed by two lines of steam railroad, one on the south side and the other on the north. These two lines have now become practically rapid transit lines, the trains running at frequent intervals into the Pennsylvania Station, New York City, and Flatbush Avenue Station, Brooklyn. It is an astonishing fact that the Flatbush Avenue Station of the Long Island Railroad accommodates more passengers than the Grand Central Terminal, the ratio being about 33 to 28. The stations on the two lines are connected by diagonals, since it was thought that these stations would be the points from which the most intense development would radiate,

these being the two points to which people would wish to go. It has worked out well; these stations have become the nuclei of several developments gradually growing up together as one Garden City. The diagonals are busy streets.

The idea in the Garden City development was for larger lot areas. The project was started by the late Mr. A. T. Stewart as a philanthropic venture, and that feeling has permeated the enterprise to within the last five years, since which time there has been a decided change. The lots were started in units of ½ acre as the smallest, when the first layouts were made, but, during the last five years, these lots have not sold well, and it has been necessary to cut them down to a unit of 120 ft. by 125 ft. or, in some cases, even as small as 80 ft. by 100 ft. In other words, one of the old street blocks, 500 ft. in width, containing lots 100 ft. by 250 ft., was bisected by a new street, which gave practically four tiers of lots instead of two. When that was done, the lots sold readily; people wanted them—they wanted to obtain a lot in the country, with only sufficient room for a house and, possibly, a garage. They did not want gardens, they wanted to live in the country practically as they had lived in the city. It may not be best, but, at the present time, it shows the absorbing power of the people in the vicinity of large cities.

On the west coast of Florida, below Sarasota, there is a condition, similar in a way, to that on Long Island. The land is flat and borders on the open sea. On the Florida seaboard, there usually are keys which form bays between the land and ocean or Gulf, instead of permitting an open coast. This particular stretch of land is acknowledged to be the only point on the peninsula of Florida where the high land (or so-called high land; it is only a few feet above the water) comes directly out to the Gulf waters. The tract is 6 or 7 miles in length by about 2 or 3 miles in width, and has been laid off for future towns, much as Garden City was planned.

The Seaboard Air Line is the only railroad on the property, and it traverses the tract almost a mile from the coast. The main town was projected on the harbor, and at points about two miles apart were located future centers which were connected with the railway stations and with the coast, and cut across by diagonals so that the people could get back and forth from their points of business to their homes, and also to the water and to the line of transit.

The problem there was to care for the people who go to Florida to make a living. They wanted larger places so that they could develop the industries of raising vegetables and fruits. In addition to the water-front developments, there were about 250 000 acres to be developed in the back country, where the land is divided into farms, with five acres as the unit and where, since people have been arriving in great numbers, the land has advanced in price from a few dollars to several hundred dollars per acre. People who have gone to Florida to live have discovered that about five acres of land may be devoted to the raising of fruits, without much extra help; that is, one man could do the work and make a living. Therefore, behind the highly developed tract on the water, which is mainly a winter resort, there are large tracts, divided by diagonal roadways, devoted to farming. These roadways consist of two strips of concrete, 18 in. wide, which are used as motor tracks. They are practical

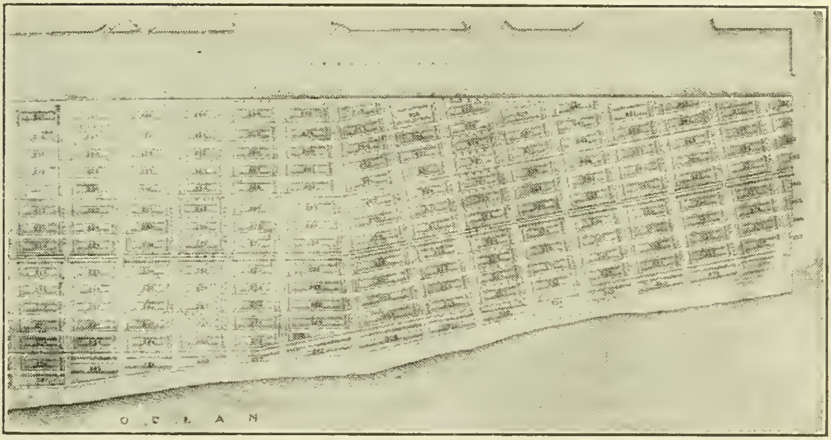


Fig. 1.—Layouts at Long Beach, Long Island, N. Y.

Fig. 2.—Pennypack Park Project, Philadelphia, Pa.

Fig. 3.—Westchester Biltmore Country Club, Rye, N. Y.

and are much used in that part of the country. When the automobiles meet they turn out on the sand which will bear the weight of a car once or twice; after that, it becomes pulverized and driving is difficult.

Pennypack Park, in the City of Philadelphia (Fig. 2), presented a different question; its location in relation to the city, and its construction, were difficult problems. The layout of the streets around the Park was difficult to work out. It seemed wise to border the Park with a street, instead of, as in many cities, backing the lots on the Park. A marginal street, therefore, was built around the Park, as in the case with Riverside Drive and Central Park, in New York City. Pennypack Park has an unusually circuitous route, systematically treated with marginal streets, to conform to the street layout of this section of the city, under the definite city plan adopted.

It is extravagant to have lots face on one side of the street only, but, on the other hand, the Park and also the lots are benefited. The reaction to the entire tract probably is much better than it would be if, as in many real estate subdivisions, the streets were made so that the lots would be on both sides, with the backs of the lots against the Park. In this case the subdivision of the lots will be city lots, probably the regular Philadelphia unit of 25 ft. by 100 ft. It will be an intensive development, and the Park affords the only means, in that section, for relief from the congested condition of the city. The Delaware River is on the extreme east, and the City of Philadelphia owns a table-land between the river and the beginning of the Park. Pennypack Creek winds "S" shape through this land and sometime these lands will be developed as a city. At the present time, the House of Correction is on the property.

The unit of subdivision should be small where the city builds a park. Where no park is built, there is need of a large unit for the lot. The question of air and light in the suburbs of cities has become serious. The County of Westchester, New York, has a Commission, appointed to make a County Plan. When a problem of this kind is taken up, and the layout is discussed, it is found that the establishment of parks is a most momentous question. People do not care to give up land, and the only solution is to develop parks on the lower priced land; where this is impossible, the numerous golf courses surrounding the cities are likely to solve the problem.

Golf courses largely are owned by golf clubs, and may be the great salvation of the future in the development of the environs of a city. Even if they become valuable, it is quite probable that the municipalities will take them and develop them as parks when the clubs can no longer carry them.

One of the most recent developments in Westchester County is the project of Mr. J. McE. Bowman, the Westchester Biltmore Country Club, at Rye (Fig. 3). This project required about 600 acres of land and three golf courses were established practically in the center of the property. The acreage is on a great elevated plain, about 150 ft. above Long Island Sound, which lies to the south and east of the property. The Club House which is near the east border will have about four hundred rooms and is being built at a cost of about \$4 000 000 or \$5 000 000, in addition to the cost of the land, which was nearly \$2 000 000.

Three golf courses which are the main object of this club, radiate from it. There are also tennis courts, riding schools, and polo grounds, and the other facilities that go with the country club. The land between the edge of the course and the margin of the property is subdivided into plots ranging from $\frac{1}{3}$ acre to 2 acres, which are selling rapidly. Although the property is 25 miles out from New York City, these plots are being readily absorbed, the idea being that the golf courses will form a residential park for the purchasers. The land is partly wooded, and partly in the open, but the size of the lot is a minimum for the class of people who are buying.

The people who are buying lots of $\frac{1}{3}$ acre to 5 acres, formerly bought tracts of land from 200 to 500 acres in extent. By having the small lot, with all the improvements that can be given, and the facilities afforded by that large tract of golf land, riding grounds, and other amusements, they have solved, to a certain extent, their problem of life. The speaker thinks the future of the project is likely to be good; a large tract of land held in that way is most desirable.

During the World War many of the industries of the country had to have people near them. The Midvale Steel Company built a village to house its employees. The only available land near-by was a steep side-hill, which was a difficult place to develop. All the industries along the Brandywine, in Pennsylvania, are in the bottom of the valleys and, in this instance, a diagonal road, on a fairly steep grade from the lower level to the upper level, was the only way to get up the hill. The streets were laid out from that road, following the contours, the idea being simply to give the workingmen the smallest piece of land that would afford a house which would not be a block house, as they wanted their individual houses. The plans were developed in that way, and the houses were built, and this development became a permanent part of the Town of Coatesville, Pa. It was not just a village that was built to be destroyed after the war, as many were, but it was a permanent addition to the town. The houses were built about as close together as possible. There was no attempt to have gardens, the people did not seem to want them; they wanted just a place where they could have a house—some of them who became fairly well-to-do during the war, had a garage.

The layout near Wilmington, previously mentioned, is practically an extension to that city. The Brandywine is a circuitous stream, which makes its environs the more interesting. The northern boundary of this development is about fifteen miles below Coatesville, and the City of Wilmington is on the south. The tracts of land that were taken for the addition, are on the east side of the Brandywine. Between the city and this tract of land is a large property which could not be obtained. Part of it is owned by the city and is used for reservoirs, and a part is owned by an interest which probably will sell at a future date, although it has not done so at this time. To the east is the intensive development of these 5 000 acres lying near the Brandywine. The land is called Brandywine Hundred, as in the original deeds given by the King. Through the development are parks and diagonals connecting the various centers with the outlying district. The City of Wilmington is an old-fashioned layout, being one of the first developments in the United States.

It has gradually been expanded with the thought of fairly large city lots. That motif will be carried through this new development; instead of city lots, they are about 75% larger in Wilmington than they are in New York City or Philadelphia.

The desire for a small lot, about 25 to 35 min. drive from the city, is illustrated by the development planned for a piece of land at Bryn Mawr, which is in "the movie zone", just outside of Philadelphia. After careful study, it was found that the entire surrounding country was intensively developed, largely with good-sized houses occupying almost the entire lot. In the suburbs of Philadelphia, the houses are from 50 to 75% larger than houses in the suburbs of New York, and are much better built. It was found, however, that nearly all the owners of houses had sold all the land except enough for the house and a garage, but no garden. The development at Bryn Mawr, therefore, has been laid out to give to each lot only sufficient land for a detached house and garage, and practically nothing else. Formerly, in developments, it has been felt that gardens were necessary, and it still may be so, but people do not want them. If land is to be cut up for disposition, it is impossible to sell more than is wanted at the time of sale. In a few years, when the property is embraced within the city, the amount of land will be reduced, the houses will be torn down, and block houses will be built. Two of the present lots may afford room for three houses, so that it is not only wise, but positive economy to place these streets now at about the right distance apart for the future development of the city, which will embrace, eventually, these suburban territories.

HOUSE DESIGN

By Andrew J. Thomas,* Esq.

Whether one deals with the City of New York, or any other city, housing in tenements is the same. During the speaker's study of this work, many complex problems have arisen, which pertain not only to technical matters of construction and of plan, but also of convenience, finance, economics, and, among others, the most important of all, the human element.

Owing to the high cost of building in the last year or two, the speaker has had occasion to study the economics of the situation more than in the past. Fig. 4 shows two plans which demonstrate what is meant by economics, bearing particularly on zoning, light, air, and ventilation. These two plans occupy corner lots, 100 ft. by 100 ft. in size; they each have rooms of approximately the same size, and have 32 rooms to a floor, therefore they furnish an unusually good unit basis of comparison.

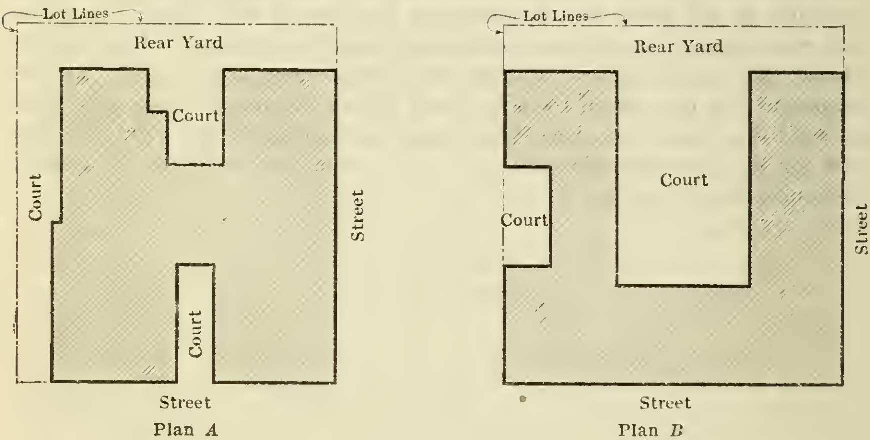


Fig. 4.

Plan *A* was adopted by the speaker before the World War, and it is possibly the first of its kind designed and carried out in a constructed building in New York City. It was extensively copied and, therefore, it may be said to be a type plan in New York City. It covers 7 900 sq. ft. of building area on the 10 000 sq. ft. of the lot, or 79% of the site. Plan *B*, however, covers only 6 200 sq. ft. (62%), or 1 700 sq. ft. less than Plan *A*. Since both plans have the same number of rooms and the same rentable area, it is obvious that the 1 700 sq. ft. of excess floor area in Plan *A* over Plan *B*, may be looked on as wasted space.

There are other points in favor of Plan *B*. Its rear rooms are lighted by a court, 37 ft. 6 in. wide, which width is regarded by the Tenement House Department of New York City as being almost a garden. In fact, it ceases to be a court. Plan *A* has courts only 12 ft. and 20 ft., approximately. How

* Archt., New York City.

much finer is the light, air, ventilation, and cross-ventilation and—the human factor, the livability—in Plan *B* than in Plan *A*! Furthermore, with Plan *B* the Tenement House Department has granted permission to remove the fire escapes from the street front of the building and to place them in the court, whereas the law states that any fire escape with exit leading to the street, shall be placed on the street. This street location of fire escape is a characteristic of Plan *A*. Because of the great width and the superior openness of Plan *B,* the authorities have granted the concession of placing the fire escape in the rear. To the speaker this seems a great advance in housing planning, because it takes from the city streets the unsightly fire escapes which are an encroachment on the sidewalk and a detriment to real estate values.

A peculiar situation with regard to Plan *B* is that, after this saving in planning has been made, by squeezing out of Plan *A* about 1 700 or 1 800 sq. ft., which means a saving of, approximately, $40 000 or $50 000, based on $0.40 per cu. ft. of cost, the financial interests in the City of New York will not lend as much money on Plan *B* as on Plan *A,* notwithstanding the greater economy of plan and construction of the former, and its far better conditions in respect to light, air, and ventilation, and removal of fire escapes from the street. Plan *B* has the same, or perhaps a little greater, gross rental income, due to its better situated rooms, a $40 000 less construction cost, and a much lower maintenance and depreciation cost. It is a much better business proposition than Plan *A,* yet it is penalized on a loan. This seems a strange condition, and the speaker feels that it is his duty to point out to the members of the Society this drawback in housing.

After Plan *B* had been developed, the first man to come into the speaker's office was told of the new plan and what it could do for him. He said, "That is all right, if you can show me a saving of $40 000 in a structure of that sort, I shall be very glad to pay you $1 500 or $2 000 extra for your plan, but will the loaning interests give me the same amount on that plan as on the old one?" Without consideration, the speaker replied, "Certainly, they will".

When the new client had gone, the speaker began to realize that a building loan is appraised on a basis of the cubical contents of the building. The size of the mortgage is determined by taking a fixed percentage of the valuation of the building, as established by multiplying its cubical contents by a unit figure of building cost per cubic foot. Take, for example the cubical contents of the two buildings represented by Plans *A* and *B,* for a building five stories high. It will be found that the loan on Plan *B* will be more than $20 000 less than that on Plan *A,* regardless of its superiority in economy and desirability. The financial institutions place a premium on lost motion and waste space in a building.

When the speaker discovered this unfortunate condition, he interviewed the heads of the loaning institutions and was told that they could not give the same consideration to the improved plan. When he expressed surprise at this, they told him that the only way they knew of appraising buildings was on the basis of full cubical contents. The speaker said, "Gentlemen, do you realize that you are creating a future slum?"

Without exception, Plan *A* represents the future slum of New York. That little court, 12 ft. wide, is not adequate. It causes darkness, odors, dirt, rubbish, and other unsanitary and inflammatory conditions. Its greatest weakness, however, is in the matter of maintenance. Such a court is difficult to keep clean. Tenants, landlords and employees will allow dirt and rubbish to accumulate in the court or on the fire escapes, and, in the dim light, inspection is difficult. The experience of the City and Suburban Homes Company of New York, which, for many years has successfully housed about 10 000 wage earners at a rental lower than the speculative tenement builder can offer, is that narrow courts are so difficult to maintain that they are a weakness in a tenement plan. Whereas, with wide courts as in Plan *B,* housekeeping is exposed to the light, and to the public gaze, and fear of public opinion, if nothing else, induces cleanliness.

Plan *A* is the type fostered by many financial interests, owing to lack of knowledge of conditions of tenement housing. However, the speaker has asked the New York Chapter of the American Institute of Architects for its support in upholding sound principles of appraisal. After several conferences, the President of the Chapter appointed a committee to discuss the matter of appraisal with the loaning institutions of New York City. This committee is now proceeding with its work, and is developing a model tenement for New York City.

Another point remains to be considered in this complicated matter of tenement planning. This is the percentage of lot occupied by the building. In New York City, the law allows—together with zoning restrictions as to courts, which the speaker feels are too lenient—70% of the land to be occupied on interior plots and 90% on corner plots. Until recently, the tendency on the part of investors has been to steer as close to the law as possible. To-day, however, the laws and the building world recognize the necessity for economical construction and for admitting light, air, and ventilation into the building. Opinion differs now only as to how far land values permit such improvement. Outside of Manhattan Island, and on land costing $1 500 to $5 000 or more for a 25 ft. by 100-ft. lot, it is generally conceded that buildings are not economical when they occupy more than 50% of the area. The speaker designed a group of four-story apartment buildings in Brooklyn, which occupy the end of a city block, 200 ft. along the avenue and 171 ft. along each street, and house 96 families in three and four-room apartments. Each apartment has two or three exposures, almost like an individual country house, and overlooks, not a court, but an outdoor garden. This group of buildings occupies only 44% of the lot area, and the owners calculate that it can be rented about 19% cheaper than more congested types, like Plan *A*. The superiority of this Brooklyn group is due both to the more economical disposition of floor area, not possible in a more congested and more complex plan, and to much cheaper maintenance. The four buildings are operated by a force consisting of a superintendent, two men who tend the central heating plant in cold weather and work outdoors in warm weather, and three women who do cleaning. The buildings are kept clean without great effort, apparently. By merely taking a few steps from a point in the middle of

the group, one can inspect every court and area and fire escape of the four buildings. In this case, bad housekeeping would be in the view of the public, and, consequently, does not appear. Easy maintenance, in which the co-operation of the tenants is induced by proper design rather than by irksome and expensive personal supervision by the management, causes less depreciation.

For the reasons of maintenance, together with high cost, due to excess space and to lost motion, the stereotyped apartment tends to become slums. It is too costly and, in addition, the owner, vainly struggling with the heavy depreciation, cannot rent his property at a figure high enough to allow for proper maintenance, and it is permitted to degenerate into slums. During the period of depreciation into a slum, the tenement is apt to pass through one or more foreclosures. Such is the history of many tenement properties.

Tenement house management is a business in itself, and the reason for its backwardness is that heavy depreciation is laid to carelessness of tenants, whereas careless planning of the building may be blamed. One can deal with slovenly tenants, but nothing can be done with an inefficient building. Defective plan arrangement promotes slovenliness in tenants.

As a result of a growing appreciation of the importance of these factors of maintenance and their relation to depreciation, the difference of opinion still existing resolves itself into the question of how far congested types of plan are necessary on the highest price land, such as the crowded areas of Manhattan Island. The working classes, obviously, cannot be housed in high "elevator" structures, and the five or six-story "walk-up" is their only salvation. The speaker has demonstrated, to his own satisfaction, that the maximum area that can be covered economically in interior lots is between 50% and 60%, and only a little more than 60% on corners, very small frontages being disregarded in this comparison. Plan *B* covers 62%, and has the same number of rooms of the same size as Plan *A*, which covers 79% of the land, and it can be built for less money. One can still reduce the size of living rooms and bedrooms, and thereby increase the number of rooms, but not many more—and still keep them fit for human habitation. Satisfactory housing is impossible as long as bedrooms of the minimum legal size allowed in New York City are permitted. A bedroom 7 ft. wide, to accommodate two persons during hot weather, does not promote efficiency or happiness. The speaker feels that studies now being made prove that for those who can afford to live in new housing on expensive land, the most economical housing is in tenements covering from 50 to 60% of the area of a 100 ft. by 100-ft. interior lot, which contain as many as 42 rooms per floor, in three, four, and five-room apartments. The room sizes are naturally small, but may still be within the bounds of decency. Such a high number of rooms per floor, however, presupposes elimination of excess space and lost motion, such as is hardly ever attained in this class of planning. Even with 42 rooms per floor, 6 of them will face on a side court 6 ft. wide, along the party wall extending from street to rear yard, a condition which will give fairly good ventilation, but not much outlook.

In conclusion, the speaker believes that if all would join in the movement to further sound planning and finance, it would strengthen the zoning principle. If by zoning laws a better and more efficient planning of streets and cities is effected, of what good is this work if a type of house such as Plan *A*—uneconomic and a future slum—is going to be built? In the larger cities, with high land values, the speaker believes the only economic way to house the people is in multi-family types of dwellings.

CERTAIN ASPECTS OF THE NATIONAL HOUSING PROBLEM: PLANNING AND ZONING

By Morris Knowles,* M. Am. Soc. C. E.

The National housing problem still exists, even though industry is rather quiet at the present time, and the cities are not attracting as many people as during the World War. It appears, however, that many people, having entered the field of industry on account of high war-time wages, now dislike to return to the rural districts after having obtained a taste of city life. The problem of housing these additional workers was felt so keenly during the war that the Government designed and built many new and complete towns. This helped to relieve the situation to some extent, but was insufficint to make much of an impression on the National shortage, caused by a general lessened building program.

When factories are again operating on a 100% basis, the housing shortage will be felt more keenly, especially in industrial communities, where it will be necessary to provide homes for employees. The necessity is obvious, since, during the war, a lesson was learned from the keen competition resulting from labor flocking to those industries having more attractive housing developments and better facilities for living.

Fundamental Considerations

One answer to the question of how to solve the housing shortage, is to provide more houses. More houses require more building lots and these, in turn, require more sub-divisions, more streets, more utilities, and miscellaneous facilities.

Housing developments may be laid out as: (1) New and complete villages; or as (2) additions to existing cities and towns.

The first will obtain in connection with new industries to be located at some distance from already established communities. There is no definite assurance, however, that industries will be in a position financially for some time to come to embark on extensive housing undertakings, and, on the other hand, there is some tendency for factories to establish themselves on the outskirts of existing cities. It would seem, therefore, that the most pressing problem of the immediate future is that of providing proper and adequate additions to already existing communities.

With this tendency to increase the population of established cities and towns, it is well to consider the effect of housing operations on the community spirit and life. In a general way, the greater the number of home owners, as distinguished from transients and rent payers, the more can one expect sound industrial relations, civic pride, and community progress. If these advantages are to be gained, the home purchaser must be offered the attractive surroundings resulting from proper planning and the security against undesirable encroachments provided by zoning.

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Successful housing—in the larger sense of the word—requires careful consideration of such phases of city planning as:

(1) Topography, natural resources, and facilities.
(2) Traffic, transportation, and street facilities.
(3) Public utilities and public works.
(4) Areas for residences, business, and industries, that is, districting.
(5) Areas for parks, playgrounds, schools, cemeteries, and public buildings, etc.
(6) The protection of these areas by zoning regulations. In other words, the actual planning and zoning of housing developments is a matter pertaining directly to the general field of city planning.

Whether such developments are made as separate communities, or as additions to existing cities and towns, they require careful consideration. A definite and orderly study must be given to each problem, incident to the evolution of a comprehensive plan.

There is an opportunity for accomplishment in the planning of an entirely new community, which is not presented by ordinary sub-divisions or real estate developments in connection with older municipalities. Many of the factors, such as the character of the buildings, or the amount and movement of traffic, which are frequently problematical in the latter instances, can be made somewhat more determinate in the planning of an independent town. The new community can be planned intelligently, therefore, to meet definite requirements and conditions. Again, the problems and the order of their consideration will be quite different than in a revision or re-planning of older communities.

Where home sites are to take the form of municipal sub-divisions or real estate allotments, however, they must be designed so as to fit into the comprehensive plan of the city. In other words, consideration of the larger community as a whole must be made, in order to plan intelligently the new housing developments. Thus, the proposed traffic arteries will be contiguous with existing ones; schools, parks, playgrounds, civic centers, etc., will be provided where needed, and, in fact, all the facilities will be an integral part of the whole working plant—the city.

Consideration of the Plan

There are two necessary closely related steps which have been found advisable to consider together, after the general requirements of the housing project have been determined. These are: (1) the main lines for traffic and transportation; and (2) the sub-division of the land into the various areas best suited to their prospective uses and the regulation thereof by zoning laws.

It has been too often the case that real estate allotments have been laid out irrespective of transportation requirements, public utility necessities, and arrangements, and the areas best suited to business, industry, residence, or parks have been ill chosen. These should be chosen with respect to the possibilities of economical development and their "fitness to function".

One of the important needs is sufficient legislation by which a plan or layout for housing sub-divisions may be made effective and not shifting or

changeable. In addition, laws providing for district, as well as abutting, assessments for improvements and laws for excess condemnation and fixing of future street lines are all helpful and necessary for completing the fulfillment of adequate residential areas.

Traffic and Transportation

The sub-division of the land should be accomplished on a basis of transportation requirements, that is, the character, volume, and destination of traffic, and as influenced by topography. Traffic and topography have an important relationship to the location and direction of streets, their width, and grade. Traffic thoroughfares should be located so that they will connect the various centers as directly as possible. Modifications and deviations from the straight line will necessarily be made, in order to keep cuts and fills within reasonable limits and to prevent damage to adjoining properties. In locating traffic thoroughfares, the relationship to the sub-division of property is of relatively minor importance.

Secondary thoroughfares, however, should be planned with some reference to the sub-division of property, particularly to avoid division into awkwardly shaped lots. Directness, nevertheless, should not be unduly sacrificed, although it is not as important as in the case of arterial thoroughfares.

The planning of residential streets is more closely connected with property sub-division. The principal purpose of such streets is to provide access, vehicular and pedestrian, to and from the houses; and to afford an open space between the houses, thus providing light and air. The relation of the residential streets to the primary and secondary streets of the housing village is of great importance. It is desirable, for a number of reasons, to plan the former, and their connections with the secondary and major streets, so that a free outlet to traffic will be afforded, without attracting through traffic and heavy hauling into the residential streets. This is not to be accomplished so much by imposing objectionable difficulties in the way, such as excessive grades, too narrow widths, or by kind of paving; but by inviting traffic to the main highway, by the superior facilities and convenience afforded. Such regulations of traffic can be further affected by making traffic routes through the residential streets relatively indirect, compared with those maintaining on the main highway.

Zoning and Districting

Effective planning means little if its beneficent results are not protected by zoning regulations. The districting of the city as a whole, and the limiting of various classes of business and industry to certain areas, give a permanence of plan and a protection against encroachment, which should be assured to the home owner.

With the primary districting plan well established, it becomes desirable to provide various residential sub-districts, dependent on the contemplated size of the project and variety and type of houses called for by the character or classes of the people to be housed, the required size and shape of lot, and the cost of the land. Districting consists, primarily, in utilizing the various parts of the town and parcels of land in such manner as to serve the health,

safety, and welfare of the community to the best purpose. Furthermore, it should include the definition of restrictions or zoning, to establish the districting policy and to insure permanency in the use of property. It is necessary, not only to make the most effective use of the property and to build on the most adaptable ground, but also to protect the future purchaser.

If zoning regulations are promulgated and enforced from the beginning, they will define the development of districts for many years to come. Such regulations are now being enforced in a number of American cities and are being upheld by the Courts. They insure that the purposes of the development will be obtained and, at the same time, protect the interest of the community and the individual. It is of interest, therefore, to note that the United States Department of Commerce, in the wisdom of its Secretary, Herbert Hoover, M. Am. Soc. C. E., has planned to promote intelligent and wise consideration of the subject, by the dissemination of information directed to call attention to the important and necessary details of this subject.

Such regulations, although an exercise of the police power, must necessarily be based, in the first place, on careful designing and the study of probable use. The separation between various districts should not be made too evident, in order to avoid the creation of a prejudice against the property of lower value. A watercourse, ridge line, woodland strip, parks, or other topographical features may be utilized as a desirable means for the purpose. The various residential districts should preferably be contiguous, thereby reducing the outlay for schools, fire protection, and, generally, the cost of utilities.

Among the various areas desirable for different purposes in a new town, or in addition to an already existing city, may be mentioned the following:

(1) Industry.
(2) Business.
(3) Residences.
(4) Civic and community centers.
(5) Schools and playgrounds.
(6) Parks and parkways.
(7) Churches and cemeteries.
(8) Public and semi-public areas, such as, hospitals, children's homes, etc.

The extent to which the foregoing areas are to be introduced into the plan of a housing development will depend largely on its size and location as well as its relation to other and adjoining communities. The various elements and their underlying requirements heretofore noted are more or less interrelated; and their incorporation in a town plan is the problem of co-ordination and adaptation. Too much emphasis cannot be laid on the importance of consistent and co-ordinated planning; on the necessity for careful consideration of the essentials of each element or feature; and on the merging of the whole into a well-balanced program.

Residence Areas

The number of dwellings per acre, or the building density, shows the degree to which the property can be occupied and affords the common basis

of comparison of use. It is, therefore, the measurement of the saturation of the plan and also an index of housing conditions. This is best expressed by the number of families housed per gross acre, including the street area, but excluding parks and open spaces. In any particular location, the greater the number of families housed per acre, the less the cost per unit, which will result from the plan. A high density, however, brought about by crowding a large number of families on small lots, with narrow streets and lack of open spaces, is poor economy and bad design. It leads to undesirable living conditions, the correction or prevention of which is the object of planning and zoning.

Density will be influenced by the type and grouping of houses, the width of streets, and the space allowed for front yard, back yard, and between houses, rows, or groups of buildings. A comparison of building densities will indicate the real situation only in a general way, as the disposition of the open space provided and the degree in which it is useful is as important as the amount. Detached houses, placed closely together, may afford an amount of total open space nearly as large as row houses, but the side-yard space may not be useful in adding to convenience and in providing necessary light and air, in fact it may be detrimental. When the cost of land is high, the number of families housed per acre may be increased, and this can be done best and most attractively by building row houses, apartments, or two or four-family houses, rather than by crowding detached or semi-detached houses on small lots.

The simple but often neglected relationship between streets and grading and house location in a residential sub-division will serve as an illustration of the interdependence between the different items of the plan. Streets should not only be located and graded so as to fulfill the requirements of traffic, access and drainage—their prime functions—but they should be also fixed, with proper regard to economic and desirable house locations, in order to minimize the cost of lot gradings. The excess or deficiency and the proposed disposal of materials from street excavation may well be a factor in the development of design for lot grading. Also, the use and location of alleys, with their attendant expense of construction and maintenance, will depend very largely on the type and grouping of the buildings. Illustrations, such as the foregoing, could be multiplied indefinitely, showing the necessity and practical benefits obtained by the working out of a carefully considered and comprehensive plan before beginning work.

It is necessary, therefore, that the streets and lots should be studied and located as a unit. The designer must constantly have in mind how the lots may be developed, the approximate elevations of the houses, the relation of the front yard and the street, and the possibilities of private driveways within the lots for use of automobiles and service wagons. It has been too often the case that streets have been located with regard to cuts and fills within the street lines only, leaving the property owners on either side to develop their lots as best they may.

Street gradients should be established on a basis of their effect on the abutting lots as well as the necessity of maintaining minimum street grades. Improper street gradients often produce such undesirable lots as to make

them almost unsaleable. The relationship between existing and proposed gradients of streets located parallel with the slope may be quite different from those streets laid out at right angles to the slope.

The utilities necessary to serve the community must be considered as a fundamental problem in connection with the layout and, therefore, must be studied at the same time. In addition to being carriers of traffic the streets may also serve as the convenient locations for utility lines. Drainage and sewerage can be effected far more economically if reasonable consideration is given to the requirements of lines and grades of streets. The location of a street in a valley, in such a manner that it unnecessarily crosses the drainage line, thus introducing rising grades, may require excessively deep cutting for the sewer. Again, it may be possible to locate a cross street on a line that will not only serve the requirements of traffic and access, but also afford the best available location for the sewers and drains. If this cannot be done, it may be necessary to undergo extra costs to lay the sewers and drains on private easements, or to follow an indirect route, both of which are objectionable for many reasons.

Conclusions

It is desirable to emphasize the necessity for a comprehensive study and plan for all village developments. The construction of housing projects properly planned does not cost any more than for those constructed with little or no planning. In fact, foresight in planning for future requirements often saves the community many thousands of dollars in the cost of street widenings, street maintenance, condemnation of land and dwellings for parks and playground purposes, and for many other items.

There is a definite need of education and appreciation by all as to the economics and advantages to be gained by having housing projects properly laid out and developed and thus protected by adequate zoning regulations in order to promote the health, safety, and welfare of the community.

The housing problem comprehends not only the need of buildings, but also an opportunity for community progress. Village projects should be conceived from the broad view of the city planner and gifted realtor; executed with the experience and skill of the engineer, architect and landscape architect; and made permanently desirable by zoning.

TRANSPORTATION AS IT RELATES TO THE NATIONAL HOUSING PROBLEM

By Ernest P. Goodrich,* M. Am. Soc. C. E.

Until within a few years, the improvements secured in the housing situation were almost exclusively through the creation and enforcement of tenement house laws. The possibilities of improvement were greatly increased when the power of zoning was given communities, beginning about six years ago in New York City. Since that date, enabling acts have been passed in many States and the zoning idea has spread rapidly. The Hon. Edward M. Bassett, one time member of the Public Service Commission of the First District of the State of New York, and, later, Chairman of the Commission on Building Districts and Restrictions of New York City (the Zoning Commission), is authority for the statement that the enactment of the zoning ordinance of New York City, which cost for its preparation and promulgation, about \$75 000, has been of as much benefit to the community as the \$350 000 000 rapid transit system. This statement may be interpreted as depreciating the subject of transportation, but it is believed that scientific zoning will go far toward alleviating present-day transportation problems, especially as they apply to the needs of the worker for transportation between home and office or shop.

Through zoning it is possible to plan cities so that the worker may be able to live near his work in far greater numbers than has usually been possible in the past, by fixing the boundaries of commercial and residential districts and their relative areas. In smaller cities, and in sub-divisions of larger cities, it is quite within the realm of possibility for practically all the people to walk from home to office or factory and to visit the local store, theater, or school without having to make use of rapid transit facilities. Resort has been made to several plans to secure this condition. Perhaps the best is exemplified in the zoning plan, devised by Mr. George B. Ford for Rheims, France. The authorities of that city first adopted a typical American gridiron street plan for their new city. It was pointed out to them that they were losing their personality as a community and that the best American city planning practice included zoning in such a way as to bring about the best relationship between the industrial and residential districts. The city authorities abandoned their first plan, and eventually adopted the one devised by Mr. Ford. Industrial districts which were wedge-shaped, were located radially about the city, with belts between adjacent wedges in which residences should be located, together with stores along the main radials which traversed the residential belts toward the principal mercantile district at the center of the community. The residential belts were approximately ½ mile wide, so that a worker need walk no more than ¼ mile from home to factory and a much less distance to do his shopping.

If it is assumed that a residential lot is 40 ft. by 100 ft., that 40% of the residential district is devoted to streets and other public purposes, that one worker with his family occupies each lot, that for each worker 400 sq. ft. of industrial area is required, and that no worker is to walk more than ¼ mile

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from the boundary of the factory district to his home, then it is an easy matter to compute the diameter of a theoretical industrial district which would house a corresponding number of families of workers, in a belt ¼ mile wide around it. It is also interesting to note that one side of the circular thoroughfare which may be assumed to surround the industrial district, would provide ample frontage for all the usual and necessary mercantile establishments required to provide for the 3 000 workers for which the district has been assumed and for their families. By arranging a new city or re-arranging an old one, it thus seems possible largely to cut down transportation facilities.

Much progress has been made in improving transit facilities so as to carry workers considerable distances to and from work. The provision of improved facilities tends to create suburban centers with intervening, unimproved districts between them and the central part of the community. These unimproved stretches are burdens on the municipalities. Utilities like gas, water, light, and pavements must be extended into the suburbs, the mains and feeders being designed of sizes sufficient for large future increases in use, on all of which, interest and maintainance charges must be paid. The better the transportation facilities, the larger, generally are these vacant stretches and the heavier is the community burden. A curve might be drawn which would indicate this condition, in which the ordinate would increase with distance from the center.

Congestion of population is equally a municipal handicap. The wider it can be spread, the less is the community cost in the way of sickness, immorality, and the other evils of congestion. A curve portraying these elements would have a downward slope as the distance increased from the center of congestion. Were these two curves superposed, the ideal condition would obviously be the point where they crossed. In other words, just sufficient transportation should be provided to obviate congestion, but also only sufficient to create as compact a community as is economically possible.

The decrease in congestion as one moves away from the center of a community, is reflected in real estate values. The latter seem to be inversely proportional to the distance traveled from the community center. In an investigation recently made with reference to a certain district in Brooklyn, N. Y., it was found that the time zone map and the real estate valuation map on which equal-value lines had been drawn, were strikingly similar. It was ascertained that 1 min. travel on the rapid transit system corresponded with a $20 per front foot of interior lot decrease in real estate value. Assuming a 25-ft. lot at $20 per front foot, with one family per lot, from which the man rode twice each week day and his wife took four rides per week, it was found that the value of the time of these individuals was 4 cents per min. This corresponds with an annual income of about $5 000 per family per annum, which was known to agree well with the class of people who reside in the district of Brooklyn, which was studied.

All are familiar with what was done during the World War in extending residential zones around war plants, by developing transportation facilities. Except for war needs, such a process is not the best for any community; however, with large plants, this condition becomes imperative. While sitting beside a worker in a street car in Detroit, Mich., it was ascertained that this

man consumed 3 hours each day traveling between his home and the Ford Motor Plant in which he worked. He thought he was exceptional, but believed that the improved conditions, with open air and country, provided for his family, were better for them than to live amid greater congestion so that he could spend less time on the street car.

A questionnaire distributed in Cincinnati, Ohio, a year or two ago, revealed the fact that among 1 000 workers, there was a preference on the part of 90 to 95% for homes in the suburbs. The answer to the question as to why they held this preference gave an almost equally large number of answers to the effect that desirable housing facilities were not available in the down-town district where they would otherwise prefer to live. There is thus seen to be a large element of psychology even in the transportation business as it affects housing.

Concentration is being superseded by dispersion. The old-time central meeting point, to-day is being disseminated. Every school is being equipped as a social center and many community sub-centers are being built, so that there are only the larger theaters, the larger department stores, and the railroad station that are in any sense unique centers, and they can be widely separated to great advantage. The banks are opening branch banks; the post-offices have sub-stations and many stores of the chain type have widely distributed branches. There are the corner grocery and the corner drug store. In some cities, it is even possible to pay one's taxes without going to the City Hall. Such dispersion is a great reducer of transit congestion.

As far as the congested districts in cities are concerned, a tendency seems to be growing toward the elimination of street-car tracks in down-town areas. The present tendency is toward the elimination, as far as possible, of rigid street use. One sees the trackless trolley coming into use, transit facilities are being placed underground or overhead, and traffic, in all directions, is being built up by better ordinances and better regulations. This action is demanded for the benefit of vehicular traffic. It can often be secured by changes in routing and the creation of circumscribing belt lines. Ten years will probably see a great change in this direction.

The economics of transportation has become so well established that it can now be stated that the density of population and the riding habit of the residents of a part of any community determines the kind of transportation which will pay. If a 40-min. headway is indicated, it means that the motor bus must be used. Where it is 20 min., the trackless trolley is the thing. About a 10-min. headway makes the trolley line the advantageous method of transportation. With a 3-min. interval, one must go to high-speed rapid transit. On the basis of such economics, one can very nearly determine the type of system that will work out best, for example, to connect the outlying districts with the down-town section of a large community. The trolleys can go just about so far, and they should be met with trackless trolleys, with buses beyond them.

Housing is inextricably involved with transportation. The two possess psychological as well as social and economic aspects. Certain general principles can be laid down, but the specific case must be handled largely on its merits.

DISCUSSION ON THE NATIONAL HOUSING PROBLEM

By Messrs. D. L. Turner, F. W. Look, William T. Lyle, and William H. Ham

D. L. Turner,* M. Am. Soc. C. E.—There is just one phase of the housing problem that has not been mentioned. In the speaker's opinion, it is one of the most important phases of that problem—if not the most important one—particularly in a great city. Engineers think too much of the house alone, that is, of the home alone. As workers we all recognize in the United States that with the home there must also be the workshop. It is essential that the two be connected. It is essential, in any housing proposition, that transportation be considered; and yet the question of transportation is never considered except in so far as the private investor is willing to provide it.

A home may be provided with water, sewers, and light, but unless it is connected with the workshop, it is useless to those who occupy it. The transportation phase of the problem is as much a social problem, and is just as important, as any other feature of the housing problem.

F. W. Look,† Jun. Am. Soc. C. E.—When the zoning ordinance of Paterson, N J., became a law backed by the city police power, property owners, adversely affected by the zoning law, objected in that their property would be depreciated by the fact that only two-family houses next to an existing store will be permitted. That particular residential plot of land has dropped in value, compared with the recent advance of the adjoining business property. Other property owners object to the building regulations governing Class A Residential Zones.

The value of narrow, odd-shaped lots in this high-class zone, drops to 33% of the larger improved lots. Some land-owners claim unjust treatment by the prohibition of buildings in that locality permitted in Classes B and C Residential Zones.

A Board of Appeals has been instigated to regulate these and similar cases. The question, therefore, arises as to how this problem will work out; to what extent a few must sacrifice their small gains for the benefit of the entire city.

The speaker hopes the ideas expressed in the discussion of the "National Housing Problem" may soon be carried out to the benefit and progress of the American citizen.

William T. Lyle,‡ Assoc. M. Am. Soc. C. E. (by letter).§—One of the most important influences affecting the National Housing Problem is the modern zoning ordinance. Zoning, however, is closely related to the park and boulevard plan and this, in turn, to the street system. The street plan is dependent on the railroads and often on seaport requirements. Furthermore, there can be no adequate design of streets and transportation lines without regard to the location of industries and commerce. The problem of trade and manufacturing is, of course, directly dependent on the labor problem. To

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§ Received by the Secretary, February 8th, 1922.

reduce labor "turnover" by properly housing the workmen is one of the chief ends of the city plan. Thus, passing around the circle, the starting point has been reached again, namely, the housing problem, which, in its relation to zoning, is the subject of the following remarks.

The chief characteristics of modern city planning are unity and comprehensiveness. The elements of the plan must be harmonized; no feature can be altered without affecting others and thus affecting the whole plan. The writer finds it difficult to limit himself to the influence of zoning on the housing problem for the reasons already given and also because of the fact that adequate housing is only one of the benefits conferred by zoning. The other benefits re-act powerfully on the housing problem.

To define the policy and practice of zoning is impossible because of the rapidity of its development. It would be folly to limit its scope or possibilities. Those who have made a study of it during the few years of its operation are unanimous in their confidence in its potentiality. Zoning, or districting, consists in the dividing of a city into districts for the regulation and betterment of living conditions, of business, and of manufacturing. Its aim is efficiency—to divide the city's territory so that it may be put to its highest and most specialized use. Its object is the segregation of homes, factories, and business houses, and the establishment of a limited control over all building operations as far as the height, size, and use of the buildings are concerned. Zoning is the constitutional use of the police power in the interests of health, safety, and general welfare. Zoning is not merely a prohibitory ordinance, a protection for dwellings and a restriction for manufactories and business houses, but rather a great constructive power for the up-building of the whole city.

In urban life, the first restrictions on property were the fire laws which were necessary for the mutual safety of families living closely together. No one would now question the desirability of fire laws, and yet they were what might have been called a violation of private property rights. Next, came the building laws which were enacted in the interest of the public health and safety, with their minute regulations concerning building materials, sanitation, size, and management of buildings, clearly a violation of the old-time idea of the sanctity of property rights. Next, came restrictions on the height of buildings, also in the interest of health and safety. Restrictions were also being placed on manufacturing of a nature prejudicial to adjoining property. Lastly, has come the full-fledged modern zoning, governing the shape and size of all buildings and the use to which they are placed, clearly also a violation of property rights, as formerly understood, and yet being sustained by the State Courts and the United States Supreme Court, not only in regulations governing future operations, but applying retroactively to those of the past as well.

Zoning stabilizes property values by eliminating speculation. Property values increase to a certain point or limit of intensiveness of use. Beyond this, congestion results; a reaction sets in and values decline. Zoning prevents inflation of values. Zoning protects the public-spirited house owner who sets his house back from the street. Heretofore, an owner has been impelled to build to the street line for his own protection. If he did not build to the

sidewalk, his neighbors would, thus pocketing his home between two projecting buildings. Many a guileless owner, trusting to the comity of his neighbors, has thus been deprived of the value of his property.

Zoning protects the home. It provides suitable home sites for both rich and poor and depopulates the slums. By preventing congestion in tenements, it promotes morality and with its requirements providing for light and air, it promotes sanitation. Zoning encourages home building and, therefore, tends to reduce the tidal movements of the city's population. No "own your own home movement" can be successfully carried through without it.

At the present time, the art of zoning is taking up advance positions. Many of its well established principles have not been tested in the Courts, though the judiciary, whenever appealed to, has quite regularly given decisions supporting the zoning laws whenever they can be shown to be based on requirements of health, morals, and public welfare. The United States Supreme Court has even gone so far as to approve of the ejection of a brick yard from the residential section of Los Angeles, giving its opinion that "a brick yard has a clear physical effect on surrounding property". However, support of this character is not invoked in the more recent ordinances, though their legality is strengthened by it.

Zoning is not so much a matter of theorizing as it is a matter of diagnosis. As an eminent engineer has said, it is four-fifths a matter of fact and one-fifth a matter of skill and judgment. Its aim is to avoid congestion. While encouraging the building of private homes, it must offer no obstruction to the building of apartment houses. It has gone on record most emphatically, however, as being opposed to congestion in tenements and to what has been called the "warehousing" of human beings. Although districting discourages certain kinds of objectionable business, it is most helpful to others of a legitimate character. Thus, by assuring prospective home builders of the permanence of the residential neighborhood in which they would build; it stimulates house construction.

In modern zoning, the town is divided into three classes of districts: First, the height districts; second, the area districts; and third, the "use" districts. Regulation is accomplished by the exercise of the police power without compensation. Districting is not concerned with the requirements of the building laws, however important they may be in matters of safety and sanitation; it deals with the larger generalities.

The height districts are determined by the broad principle of equal rights to air and light, or, as the English say, by the "ancient lights". Districting with regard to height is concerned principally with office buildings. Apartment houses must also be controlled. In cities without a zoning ordinance, apartment houses have been built so high that they cut off light and air from surrounding houses the value of which may drop as much as 30 per cent. There are two methods of regulating the height of buildings: First, by a flat limit; and, second, by specifying the allowed height as a function of the street width. The latter method is the more popular and has the merit of encouraging street widening, since the wider the street, the higher the building may be.

It has been said that "the problem of the last generation was the supply of gas and water; the problem of the next is to provide light and air". Merely limiting the height of buildings is not enough, for a building may cover the entire lot and, therefore, cut off light and air from windows adjacent. The object of area districting, however, is not only to provide light and air, but also to prevent congestion, although, in this respect, it has not been very effective. The zoning ordinance of Newark, N. J., limits the population directly on the area basis. In the tenement district in New York City, in 1914, the average density was 852 persons per acre. The Newark ordinance is unique in character, having been the first effective attempt of its kind, in the United States, to prevent land crowding. By the Newark ordinance the maximum population is 80 per acre, only about one-tenth of the New York City density.

Zoning on the basis of the use to which buildings are placed, has been sustained by the Courts of several States and by the United States Supreme Court. The most up-to-date practice of zoning calls for four "use" districts, the residential, the manufacturing, the business, and the unrestricted or nuisance.

"A city is something more than a place to work in", says H. S. Swan, "it is also a place where people live, and although people must work to live, they must live to work". Living conditions will rightfully be considered first. The residential district is sometimes divided into two sub-districts, one exclusively for single-family homes and the other for single-family homes and apartment houses. Since in some cities there is doubt as to the legality of legislating on the basis of the number of families in a house, the requirement is made that the houses in the exclusively residential district may not have more than two stories, thus effectively legislating against tenement conditions. Owing to the evident need for apartments by small families and by those who are not in a position to buy or rent a single-family home, apartment houses must be recognized and allowed. Their construction, of course, must conform to the building code and their height and area to the zoning requirements. The apartment house districts are near the business district and are determined by apartment houses already built. In the same district, single-family dwellings must be permitted, although the district will become more undesirable for such dwellings and more desirable for apartments.

The housing problem must go along with the transportation problem. Without proper transportation, houses will be huddled together, especially workingmen's homes, thus resulting in abominable social conditions. With adequate transportation provided by the city plan, the residential zone can extend to great distances from the centers of industry and business, thereby securing the advantages of air, light, and quiet. In planning the residential district, consideration must also be given to the wishes of those who prefer to live near the scenes of activity. Many workingmen prefer so to locate, and their wishes should be respected. At the same time, the contrary principle must be borne in mind by the planner, that owners and renters do not know what is best for them, that quite frequently people of small means live on expensive land and people who are wealthy live on land that is cheap. It would

be far better, in many respects, if working people could be induced to live at a distance from their places of business, providing that adequate facilities could be provided for their transportation. This principle is denominated "decentralization", and is the cardinal idea in the building of what are called, "garden cities". Another method of dispersing the residential population is by inducing the factories to remove to the outlying regions. Heavy industries such as iron founding and steel manufacture are often willing so to remove; but even with this accomplished, there is still the danger of slums and congestion about the new center.

The manufacturing district is located with respect to railroad, wharfage, power, and labor facilities. Of these requirements, the labor problem is one of the most important. To reduce labor turnover is one of the manufacturer's chief concerns. The municipality by providing him with facilities for obtaining and retaining satisfactory labor is rendering him a great service. The city is in a position to perform this service by passing suitable zoning ordinances to protect the homes of his employees and to provide them with means of transit.

The business district is located in the heart of the town with radiating streamers extending out along the principal highways. In it, the interests of business must be conserved by prohibiting manufacturing and objectionable trades. Some authorities would also prohibit residences.

The unrestricted or nuisance district accommodates industries not permitted in the manufacturing district. There is, however, a serious objection to making any district unrestricted, owing to the tendency of human beings to live there, under conditions prejudicial to health and safety.

Using the word, "district" in an entirely different sense, there are also the so-called "blighted districts". Blighting is the dread of real estate operators and investors and is the direct result of unregulated building. A factory or garage may intrude into a residential district and ruin values in all directions; so, also, may an apartment house, constructed in a high-class residential district. Zoning is as good a protection as life or fire insurance and possesses the great advantage that it costs practically nothing. Then, too, there are improvements which produce blighting, "depreciatory improvements", as they are called. Thus, a surface or elevated car line will quickly blight a residential district, a municipal gas plant, a business district, or a change of railway location, an industrial district. To prevent "blighting" is one of the chief objects of zoning.

William H. Ham,* M. Am. Soc. C. E.—For the complete plumbing of seven types of houses, the speaker obtained cost figures which varied from $408 to $475 per home, using 1-in. steel pipe for the water supply. The use of wrought-iron pipe would have added about $8 to the cost, and brass pipe from $35 to $38. The cost of piping is a small part of the cost of the house. These houses averaged in value from $4 000 to $8 000.

The selection of the proper kind of pipe is a serious question in all communities. The speaker wishes to inquire whether some water supplies are of

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such chemical quality that the use of brass pipe is inadvisable, and whether there are any data on the carrying capacity of new to four-year old brass pipe in comparison with the capacity of steel or iron pipe of the same age? Such data would be desirable to people who are buying homes. The speaker is removing a certain kind of pipe in thirty-nine apartments, in which there were 120 leaks in the hot-water system alone, and about the same number in the cold-water system. The $1\frac{1}{2}$-in. pipe is being replaced by 1-in. pipe, and the $1\frac{1}{4}$-in. pipe is being replaced by $\frac{3}{4}$-in. brass pipe. The speaker did not know, before he investigated the subject, that for a $5 000 or $6 000 house the difference in the cost for the use of brass pipe from the street to the house, and out to the hose connection, was only $38. Such matters should be brought to the notice of the public as they are important facts which affect the housing situation. The speaker's company bought from the Government 257 houses in which steel pipe was installed, which will have to be removed in about 6 years. After $2\frac{1}{2}$ years of use, some of the pipe is rusted to such an extent that it is being removed in the damaged places.

It would be well if water supply engineers not only codified these facts, so that instead of using $1\frac{1}{4}$-in. steel pipe, one might use $\frac{7}{8}$-in. or $\frac{3}{4}$-in. brass pipe, but also furnished data as to localities in which brass pipe may be safely used.

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PAPERS AND DISCUSSIONS

HIGHWAY TRANSPORTATION*

A SYMPOSIUM

By Messrs. H. E. Hilts, Frederick Stuart Greene, and Herbert S. Sisson.

With Discussion by T. Hugh Boorman, Samuel Whinery, John C. Trautwine, Jr., Eugene W. Stern, Henry Goldmark, and H. W. Brown.

* Presented at meetings of January 20th, 1922, and continued from February, 1922, *Proceedings*.

HIGHWAY INSPECTION

By H. E. Hilts,* Assoc. M. Am. Soc. C. E.

It has been found in the Pennsylvania State Highway Department that, in connection with the construction of a large mileage of durable highways, the work of the executive is that of an adjudicator and that the work at headquarters is simplified and systematized by the careful manner in which inspection work is handled on the construction contract. Mr. MacDonald† has expressed the thought that inspection is not just inspection on contract work, and the speaker believes that all will agree that his views are conservative, but, nevertheless, the inspector can many times reach decisions that will lessen the work of both the district office and the main office of a department. The design of highways is subject to standardization and work of this character can be systematized. Plans also can be carefully checked, but inspection depends on the man assigned to it; therefore, all inspectors should be selected with care.

The work of a survey corps can also be systematized and checked, but after the work of an inspector has been done, checks may be made, but errors are costly to correct. In Pennsylvania, candidates for inspection work are not selected by Civil Service, the policy of "hiring and firing" being preferred. It is believed that all inspectors should be interviewed at headquarters before being employed, the candidate, on being employed, is told that he should consider himself a servant of the public, and that as far as emoluments of office are concerned, he must also realize that the satisfaction of building a road that is a credit to the Department and to the Commonwealth, must serve, in his own mind, as additional recompense. He is told that as far as the Department is concerned, he is not merely building Route Number so and so, but in the future the contract on which he is employed will be known as the road that Inspector "Smith" supervised. In other words, an attempt is made to appeal to the human element and arouse the candidate's ambition so that he will deliver a real job.

The inspection of construction is only a small part of inspection work. Preliminary to the making of surveys for the preparation of plans, the district engineers inspect existing roads, which they know will be improved in after years. In other words, every trip a district engineer makes over an unimproved road permits him to visualize re-locations or changes in roads, and in the spring of the year these trips are particularly valuable in the inspection of drainage conditions.

All construction plans are premised on careful studies of drainage, and an endeavor is made to locate both sub-surface and surface drainage structures so that they will answer not only the ordinary conditions, but also such extraordinary conditions as developed during the heavy winter of 1919, when roads that had been constructed for years, gave signs of distress during the spring thaw. These inspection trips, as they respect drainage, should be summarized

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* Prin. Asst. Engr., Pennsylvania State Highway Dept., Harrisburg, Pa.

† *Proceedings*, Am. Soc. C. E., February, 1922, p. 320.

by adequate notes which can be interpreted by the men in the office, who are designing the road.

During 1921, Pennsylvania constructed 678 miles of highway, largely made up of the so-called durable types—sheet asphalt or asphaltic concrete on cement concrete foundations, vitrified brick on cement concrete foundations and one-course reinforced concrete. In expediting this program, the material situation was carefully studied during 1919 and 1920. Considerable time was spent during these two years, even during the construction of 253 miles in 1919 and 414 miles in 1920, in tabulating material supplies, both local and commercial, by counties and by States adjacent to Pennsylvania. The inspection of roads by district engineers is carried to a study of grade-crossing elimination prior to the issuance of the survey authorization.

After a survey has been made on the line established by the district engineer, a preliminary inspection with the blue prints of the project at hand, is made by the district engineer and a representative from headquarters, and if the project is a particularly difficult one, this preliminary inspection is made on foot. At this time, it is decided whether the alignment chosen is the best, and in checking this feature, it has been the endeavor to teach the men that the laying out of the highway, from the viewpoint of economy, must be developed by a study of distance, of maximum and ruling grades that will set traffic conditions, the elimination of unnecessary rise and fall, and of dangerous curvature. This does not mean that in highway work, the refinement used by the railroad engineer has been reached, because in many cases one cannot visualize or even approximately determine which of the previously mentioned features of construction is the most important, whether it is elimination of rise or fall, or curvature, maximum or ruling grades, or a study toward the elimination of distance. The traffic, as Mr. MacDonald has pointed out, has changed so rapidly in the last ten years that it would appear that even the present-day engineer would have to be the seventh son of a prophet in order to anticipate traffic conditions ten years hence. The checking of judgment by figures in establishing maximum grades, rise and fall, and curvature, which really amounts to the setting of business limits for economical expenditure of funds at this time, must be premised on anticipated traffic which the road will have to bear five, ten, or twenty years hence.

Another type of inspection is that of determining the kind of surfacing material which is to be used, and it is felt that, in deciding this question, an inspection on the ground by the district office is most important, so that full data may be secured as to the availability of materials, the nature of the termini of the road, and the present and the anticipated traffic which the road will take.

It has been found that the selection of type should not be based on the first cost alone, but should represent an investment, particularly where bond-issue moneys are concerned, which will, in some measure, be available after the bonds have matured, this investment not only being made up of grading and drainage structures, but also of the surfacing material. The competition between types, where such competition is based on engineering judg-

ment, is healthy and stimulates or results in lower prices, induced by more efficient business methods in the construction of the road.

The preliminary inspection as carried on by the district engineer is made almost simultaneously with an inspection made by the engineer of tests or his representatives, who examine the availability of local construction materials, the matter of inspection many times requiring from 3 to 5 days on a 3 or 4-mile project. The representatives of the engineer of tests blast out ledges and dig test pits, so that representative specimens may be obtained, and the quantity of materials available may be determined. This work has proven to be of extreme importance. In 1919 there were only about 8% of the contracts on which local material was used. In 1920, some local material was used on 28% of the contracts, and, in 1921, there has been an increase in the use of suitable local materials, which has necessarily resulted in a lowering of the first cost of the road.

Mr. MacDonald has pointed out the necessity for properly interpreting test results. The mechanical testing of materials, in a well ordered department, is mostly by systematized routine, and the speaker feels justified in stating that the most important feature of tests is their interpretation. Experience in this work is a fundamental requirement. The speaker might illustrate by a comparison of the different kinds of stone found in Pennsylvania, which vary from coarse grained sandstones to heavy dense trap rock. There is no sand in many parts of the State, and it has been necessary to prepare sand artificially by grinding coarse and fine grained sandstones. Studies were made, which pointed to justification in using artifical sands and in using good sands in combination with relatively poor aggregates, these results having been reached only after the construction of a test road in which various types of materials were used in combination. Test specimens were studied during the construction of the road and compared with specimens taken from the road after it had been in service for a period of six months.

The speaker has dealt with inspections made preliminary to surveys and during the preparation of plans. All these inspections have one objective, that is, to have the plans as nearly perfect and practical as possible, and to submit them to the contractor so that he may have full information regarding the roadway under consideration. Each contractor is given, on his proposal form, the estimated quantities as nearly as they can be determined and on a supplementary sheet he is furnished with the local materials which might be used in the construction work, and their location, with the provision, however, that no guaranty is given as to the continuation of quantity or quality of materials as sampled. It is found that the engineers of the department have used judgment in the preparation of all this material, but it is also suggested and recommended that the contractor, before basing his bids on local materials, should analyze the location on the ground and examine the test pits and the ledges.

The final field inspection also furnishes information on which to base the time limit on the contract. A 5-mile contract has been built by an efficient contracting organization, in as short a time as 70 days; another con-

tractor not as efficient might have required 3 years in building the same project. It is endeavored, as far as possible by inspection in the field, to work out a conservative time limit for every contract.

Only the engineering phase of contract work has been considered in all the inspection details mentioned. Another phase, however, is the inspection of the business of awarding contracts. This has been accomplished in Pennsylvania by calling to Harrisburg for interview, each contractor who has been a low bidder. At this interview the Assistant Commissioner of the Department discusses with him the matter of equipment which he contemplates using on the work, this discussion being premised on a list of the major items of equipment which has been carefully prepared by the engineers of the Department. This list is prepared on the basis of the minimum amount that should be used in completing the work within the contract time, and it is thoroughly understood, by a gentlemen's agreement, that the equipment finally decided on at the conference will be used on the work. Furthermore, the contractor advises whether he owns the equipment, is going to buy new equipment, or is going to rent it. Careful attention is given, in the discussion, to the method of handling the work and as to the contractor's qualifications, based on previous experience in handling men, and as far as the labor situation is concerned, local or imported labor is discussed, and the establishment of commissaries is considered.

It has been difficult at times, during the past three years, to have materials delivered in sufficient quantities and with sufficient regularity to handle the construction work economically. Therefore, the Assistant Commissioner requires the contractors, during the discussion, to outline a fairly definite program, as to where they expect to purchase materials, so that the Department in turn from its previous experience can determine whether materials will be forthcoming, so that the contractor will experience minimum delays. It has been found that this procedure is warranted, inasmuch as it may result in speeding up the work and in reducing the hazard of having to complete one season's contract during the following season, thus causing serious financial loss to the contractor as well as to the State, inasmuch as the new road will not be completed over the winter and spring months.

In order that contract work may be handled promptly and efficiently, every contractor must have financial resources and, in the interview with the Assistant Commissioner, he must furnish evidence that he is financially able to handle the work, not from a surety point of view, but rather from the point of view of ready cash or stocks or bonds that he can use to raise money, or lastly, from the presentation of letters from banking concerns which express confidence in his ability and their willingness to finance him in an amount equal to at least 20% of the cost of the work. Following the usual practice, the contractor also furnishes a surety bond from an approved surety company in the amount of 50% of the contract cost. The interview with the Assistant Commissioner is not at all one-sided, inasmuch as he endeavors to impress on the contractors the thought that 100% work is being looked for and that plans and specifications are prepared to be followed, and, further,

that, in order to obtain a 100% job, the Department and the contractor must give each other 100% co-operation.

The inspection of materials is made at the source of supply, in order to protect the material man and the contractor, but this inspection is only preliminary. Inspection is also made at the delivery point of the contract, but this can be considered only as preliminary, the final inspection of materials being as they go into the work. It is endeavored to foster high ideals in the minds of the men by proper instructions in readable, illustrated form. The men have been instructed at headquarters and at district office schools, and three of the universities in Pennsylvania have established short courses in which particular emphasis has been given to the tenets of contract law and specifications.

Questions often have been raised as to the cost of making surveys, preparing plans, and inspecting contract work, and there is a lack of data in engineering literature on costs of this nature. Take about twenty-five contracts, which were available and on which tabulated costs have been completed; these jobs include those which have been finished rapidly and on which the plans were prepared quickly, as well as those which were studied for two or three years, and on which the contractor made slow progress, due to weather conditions, the non-delivery of materials, etc. It is found that the cost of these twenty-five contracts has averaged $524 per mile, for field and construction surveys; $175 per mile, for the preparation of plans; and $891 per mile, for inspection work; the total cost expressed in percentage of the contract price being 2.96. The cost of inspection and tests of materials has averaged about one-fourth of 1% of the contract price of the road. In other words, the engineering costs have averaged less than 3¼% of the contract price, and the speaker submits that this is cheap insurance to the taxpayers of the Commonwealth, and at the same time, furnishes the Department definite assurance that it has done its part in working out an efficient and economical method of handling contract work.

FINANCING AND BONDING

By Frederick Stuart Greene,* M. Am. Soc. C. E.

The speaker was especially interested in the bill which allows a contractor, doing work in New York State, to bond himself. When it came before Governor Alfred E. Smith there was much opposition, and the speaker urged the Governor to sign this bill, largely because of information obtained immediately after his taking office as Commissioner of Highways.

The speaker was told that one of the best contractors in New York State, a man who had never failed to carry out every provision of his contracts and who had had years of experience, had been refused a bond by all the companies. This contractor was forced to deposit Liberty bonds before the contract could be awarded to him, in spite of the fact that he was financially sound.

The speaker was informed that the State of New York had paid indirectly, since it began the construction of highways, approximately $5 000 000 for surety bonds (that is, the contractors had paid this sum and the State, of course, had necessarily paid this additional amount for the contracts), and that the State had received less than $100 000 paid in by the surety companies to compensate it for losses due to broken-down contracts. It seemed that if this was the case, it would be wise to permit the contractors a chance to show what they could do toward bonding themselves.

For these reasons the speaker urged the Governor to sign the bill which allows the State to retain the contractor's bidding check, amounting to 3% of the contract, until the amount of the retained percentage equals that check, whereupon the check is returned to the contractor. The speaker is glad to state that it was possible to deposit these checks so that they might draw interest, and the interest was allowed to the contractor on the return of the check.

For the information of commissioners in other States, there were two faults in the New York Bill: It allowed the contractor to elect whether or not he would give a surety bond. This option should be left with the Commissioner. One case arose during the speaker's term of office, where he was not willing to allow the contractor to proceed without a surety company's bond, and his only recourse was to declare that if the contractor did not put up a surety bond the Commission would throw out all bids and re-advertise.

The greatest objection brought against the bill of retaining 20% as a safeguard to the State was that it would encourage unbalanced bids. The contractor might bid a high price on excavation, for example, and a low price on pavement. After finishing the excavation at a high price, he might then abandon the contract, thus leaving the State to take care of itself. The solution of this was easy. The Department made a ruling that no proposal would be received in which the price for any item exceeded the engineer's estimate for that particular item more than 10 per cent. This placed the responsibility where it should be, namely, with the Department and with its engineers, to see that they did not have an unbalanced estimate which, in turn, would permit the contractor to submit an unbalanced bid.

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The experiment of permitting the contractors to bond themselves has been proven to the advantage of the State of New York. There is only one contract that the speaker can recall, by which the State sustained a loss, and this may prove to be only a probable loss. In all other cases, where the contractor has bonded himself, the plan has worked satisfactorily.

The speaker would like to suggest an improvement to the present law. The State now holds 20% until the actual completion of the contract. This might result in an undue hardship to the contractor. For instance, suppose a contractor has completed, in the late Fall, all his contract except some minor detail. The Commission could then hold 20% of all the work done, during the winter, because of the non-completion of only a few dollars' worth of work. The speaker is glad to say that in the State of New York there is a ruling which was carried on under his administration, and is now being carried on under Commissioner Sisson, which allows the contractor having only a small amount of work left to do, to file a bond or sufficient cash with the Commission to cover this work, and the contract is then accepted and paid for.

To obviate this fault in the law, the speaker believes it would be more equitable to the contractor if the law was amended somewhat as follows: 20% to be retained until 60% of the work is performed; 17% to be retained until 80% of the work is performed; 15% until 90% of the work is performed; and thereafter 10% until the entire work has been performed to the satisfaction of the State.

The speaker would estimate the cost of a bond to the contractor about as follows: Starting on the basis of a \$100 000 contract: At 1½%, the bond would cost \$1 500. Remember that, whether or not a bond is put up, the State will retain 10%, and if a bond is not put up 20% will be retained. It is fair then to calculate the interest charges on only \$10 000. At the end of the contract, if no bond was given, there would be \$20 000 held, but there would be \$10 000 if a bond was given. Assume only the \$10 000 extra that would be held by the Commission, on the no-bond plan, and that this \$100 000 contract is completed in twelve months. It is fair then to assume that an average of \$5 000 of that extra \$10 000 is retained for six months; and \$5 000 at 6% is \$300, as against \$1 500, the cost of the same contract with a bond. If a sliding scale, as suggested, should become a law, the no-bond contract would be still more favorable to the contractor.

Recently, the speaker learned of a new firm starting to build highways. One of the members of this company has been in the contracting and engineering business for thirty years, and although he had never made a great fortune, he had never gone "broke". The company owed nothing and had plenty of money to go ahead with its work. This firm was solicited for its bond. The bonding agent repeatedly urged the President to close the transaction with him, and finally was told to write the bond. When the agent sent the bond to his main office, they refused to write it, and at the start of its business career this new company was placed in a bad light with the State, which was about to award it the contract. Fortunately, another bonding company wrote the bond which amounted to \$3 000. The firm has been paid for its \$3 000, the contract is completed, and, more wonderful than all, the contractor made some money on his work.

FINANCING AND BONDING

By Herbert S. Sisson,* Esq.

The subject of automobile taxation has a vital bearing on the highway situation in the State of New York. The speaker believes it is estimated that in 1922 the total revenue from automobile taxation will be more than \$10 000 000, which would average about \$12 per vehicle, in the State of New York. The law provides that a motor vehicle in the State of New York may not be taxed as personal property, which means that the value of the automobile is not taken into consideration as personal property and taxed as such. The only tax that an automobile pays, or an automobile owner pays on the money invested in the machine, is his license tax. This, the speaker believes, is not the case in some States. He does not believe that the automobilists of the State of New York should pay for the entire cost of construction and reconstruction and maintenance and administration of the Highway Department, but he does believe that they should pay more money than they are now paying toward the reconstruction and maintenance of highways. Approximately, \$9 000 000 or \$10 000 000 each year are being spent for the maintenance and reconstruction of the highway system. That will probably increase for a few years at least as the mileage of completed highways increases.

It is hoped that the type of highways now being built and which have been built for the last few years may not require the large sums per mile that are now being expended on some of the earlier built highways. That is a hope, however. The speaker does not believe that any one can foresee or foretell what the traffic conditions may be 10 or 15 years from now. Perhaps the highways that are built to-day will be as inadequate to bear the traffic they will be called on to bear 10 or 15 years from now, as the highways built 10 or 15 years ago are in comparison with the traffic to-day.

It was the speaker's privilege, recently, to converse with the Highway Commissioner of one of the counties bordering on the City of London, England. He spoke of the type of highways it was necessary to build in that locality, and particularly called attention to the kind of traffic that those highways were called on to bear. He spoke of the motor lorries, propelled by steam, which have steel tires and carry such immense loads. If that type of motor vehicle is ever introduced in the United States and used to any extent, the speaker has grave fears as to what will happen to even the best of highways that have been built or that are being built.

The speaker believes that no one in the State of New York seriously questions the advisability of a reasonable increase in the motor vehicle tax. No one intends or expects that the motor vehicles in this State are to pay the entire cost of construction and reconstruction of highways, but it is felt that the motor vehicles should pay a somewhat larger tax than they are now paying for the purpose of highway maintenance.

The speaker wishes to discuss briefly the bonding of highway contractors in the State of New York. Mr. Greene called attention to the bill that was

* Commr., State of New York Commission of Highways, Albany, N. Y.

passed two years ago, which allowed a contractor to dispense with bond by agreeing that the Highway Department could retain 20% of the estimates, as the work progressed. This works, in the speaker's opinion, as follows: When a contract is to be awarded to a contractor who is low bidder and who elects to dispense with bond, the Highway Commissioner must be the judge of whether he is financially able to carry on that contract to completion.

In case he is a new bidder and has never had a State contract, there is no way of determining whether he is financially able, and has the business ability to carry on that contract and to complete it. The speaker believes this is an unfair burden to place on the Highway Commissioner.

Furthermore, a contractor who has never had a highway contract in this State, or perhaps, in any other State, immediately finds out that he is not obliged to give a surety company's bond, and immediately concludes that this is a way of saving or increasing his profits to the extent of the premium that he would pay to the surety company for a bond. That is so, to a certain extent, on the basis mentioned by Mr. Greene, except that the borrowing ability of the contractor on the retained percentage basis is much impaired. With the contractors who have dispensed with bond, there comes a time usually when it is difficult for them to borrow money for that reason, and many of them state that, unless they can have a semi-monthly estimate, which is contrary to the rules, they will have to stop work. That has happened in one or two cases and the work stopped until the monthly payment was made.

The speaker believes that in those cases, if the contractors had been bonded, they probably would have been able to obtain money either from banks or other sources had they not dispensed with bond and tied up their payments by the retained percentages.

Under the Hewitt Act which was passed in 1921, the State of New York will have a highway system comprised of 11 260 miles. There are, either completed, or under contract, all except about 2 200 miles of this road. The question of financing the construction of these 2 200 miles has been seriously discussed, not only by the Highway Department and the present State officers, but by the past administration, and the speaker thinks it is agreed by every one who has considered the matter seriously, that it will be unnecessary to issue further highway bonds for construction purposes.

The long-time bond has become obsolete in the State, by law; and, with its great resources, the State of New York will be able to finance the building and the completion of this great system without a further issue of bonds. The people of the State of New York, and of other States, have come to the conclusion that not only in their own private business, but in public business, the policy of "pay as you go" should be adopted wherever it is practicable.

A large sum of money will be required to build this highway system, say, \$75 000 000. Of the second \$50 000 000 bond issue, there is about \$6 000 000 unexpended, of which from \$4 000 000 to \$4 500 000 will be used on construction in 1922. The remainder of this year's construction will be financed either from what is known as Federal Aid, that is, the amount contributed or appropriated by Congress for the aid of the States, of which this State gets about 5% of the total appropriation, which must be matched by an equal

amount appropriated by the State Legislature. The amount available in New York in 1922, together with the bond issue, and probably a small direct appropriation, will finance the construction of the coming season. The continuation of aid from the Federal Government and a direct appropriation by the State to match it, and another direct appropriation of some millions of dollars, will finance the program for 1923. The Hewitt Act provided that the entire system of 11 260 miles should be completed within 6 years from the passage of the bill. The rate of progress made during the season of 1921, and the expected progress during the season of 1922, will be on that average basis.

All these matters of finance, from the standpoint of the Highway Department, are the cause of much work and study. The distribution of the money and the work in the several counties of the State is fixed by law. First, the last \$50 000 000 issue was divided among the counties and, for that reason, the \$6 000 000 of that issue can never be entirely used. There will be balances of from \$1 000 to \$10 000 in the different counties, which will not be enough to finance any particular piece of work in a county. For that reason, about \$1 500 000 or \$2 000 000 can never be used, and for which, therefore, the bonds can never be issued.

It is not known whether future Congresses are to continue what is known as Federal Aid. If they do not, other means of financing the completion of this system will have to be devised by the authorities of the State of New York.

DISCUSSION ON HIGHWAY TRANSPORTATION

By Messrs. T. Hugh Boorman, Samuel Whinery, John C. Trautwine, Jr., Eugene W. Stern, Henry Goldmark, and H. W. Brown.

T. Hugh Boorman,* Esq.—This year (1922), the speaker begins his fiftieth year of practical work and investigation on road construction. In 1872, he had the pleasure of working for New York City when Neuchatel rock asphalt was introduced, and since then has had every kind of experience in road and street construction. In 1885 and 1886, he had the honor of serving on the staff of the late Gen. John Newton, Hon. M. Am. Soc. C. E., formerly Chief of Engineers, U. S. A., who came to New York City and began the more modern methods of street and road construction.

Inspection is one of the most important factors in highway work. As has been stated, and as every one realizes, the greatest work in the United States to-day is the building of roads.

In reviewing more than forty-nine years of service, one realizes how methods of transportation have changed, and to-day it is important to have good roads and streets. The education of the inspector, as has been remarked, should start early in life; young engineers on being graduated nowadays have to do something practical, and the speaker does not know why it is not just as well to start on inspection as any other line of their necessary practical experience.

Good inspection is important, and it will be, and undoubtedly is, advisable that an endeavor should be made to train young engineers to feel that a road inspector is a man who is going to be of immense service to the country.

Samuel Whinery,† M. Am. Soc. C. E.—All that has been said about the importance of good inspectors and the difficulty of obtaining them is true. On almost any public work, whether it is the building of a road, a railroad, or a bridge, there is no more important position on the whole job than that of inspector, provided he is of the right kind. The practice in the United States has largely been to select young technical graduates for the position. As a rule, they are an excellent class of men. They have had a good technical education, and it is natural to assume that they are well prepared to be competent inspectors on any kind of engineering work. So they are, in some respects, but not, the speaker thinks, in those of most importance. His own experience has been, particularly in railroad, bridge, and masonry work, that the most valuable inspector is one who is an expert in the particular kind of work he is to inspect, although he may have but little technical knowledge.

For instance, on masonry, the best inspector the speaker ever had, was a man who never attended college, who began early in life as a stone mason and followed his trade until manhood. There was nothing about any kind of masonry that he did not know. In addition, he had good judgment and the faculty of doing things in a pleasant way. Contractors soon came to ap-

* New York City.

† Cons. Engr., New York City.

preciate that, although fair and reasonable, he knew his business thoroughly, and that his instructions were the law. The speaker remembers another man, later general inspector of masonry on one of the largest railroads in this country, who advanced in the same way. He was a practical mason, trained in every branch of his work.

The trouble with young engineering graduates is that they have had no opportunity to learn from experience the matters of practical detail that, after all, are likely to make up the bulk of an inspector's duties. They understand the requirements of the specifications, which cannot always be literally complied with, but do not know when these literal requirements, in matters of detail, may or should be varied from in the interest of good work. The speaker has had similar experience in street and road work. The man who will be most useful as an inspector is one who knows the entire process of road building. Without disparaging in any way the merits, and they are many, of the college graduate, the speaker would say that it seems unjust and unfair to place him in a position for the duties of which education has only partly fitted him and in which he has had no practical experience.

The value of a technical education as a qualification for the position of inspector on public work may well be questioned. Aside from the mental discipline that a course in college develops, or should develop, it does little to qualify a young man for the duties of inspector. Such duties are almost wholly of a practical nature, a knowledge of which can be acquired only by experience, observation, or special instruction, regardless of technical training.

The speaker has had some experience with inspectors in cities and on country road work. The chief trouble, of course, results from the appointment and retention of incompetent men for political or personal reasons. Even in cities where Civil Service examinations are required, one will find, as inspectors on the streets, men who are incompetent and whom one would not trust in any responsible position. They are ignorant of the duties required; they serve the interests of political bosses rather than those of the city; and, too often, they accept, if they do not demand, gratuities from the contractor.

About ten or twelve years ago, the speaker was asked to report on paving conditions in one of the large cities of the United States; and, among other things, he looked into this matter of inspectors. He thinks he is perfectly justified in saying, not from suspicion, but from proof presented, that three out of five inspectors on the streets received regularly weekly pay from the contractors. In another city, where he was somewhat in responsible charge, and where he found incompetent inspectors and was able to secure their dismissal, he would find them, a few days later, as inspectors on a street in some other part of the city. Incompetent and dishonest inspectors give the unscrupulous contractor an opportunity to "scamp" his work and then attempt to evade responsibility by claiming that it was done under the supervision and with the approval of an agent of the municipality.

As the result of his experience and observation, the speaker believes that the best inspectors, for nearly all kinds of public work, come from the ranks of intelligent and honorable men, who, as craftsmen, have acquired a practical knowledge of the work.

John C. Trautwine, Jr.,* M. Am. Soc. C. E.—The papers on this subject have dealt largely with the economic or sociological side and relatively little with the technical side. The speaker, therefore, may say a word further respecting the sociological aspect of privately conducted water and rail transportation, as contrasted with publicly conducted highway transportation.

The people, to-day, are in a situation, the like of which the world has never before seen. What the speaker will call the "ancient" system of individualism and the "modern" system of socialization are to-day still traveling side by side, like a muddy and a clear current in the same stream.

Under the "modern" system, the community gives to each one regardless of merit, all the highway facilities there are, and one can get no more of such facilities by over-reaching his neighbors. Thus, the tendency to over-reach, which is the soul of private business, is becoming atrophied for want of use. Even in the purely socialistic furnishing of public highways for the free use of all, an operation in which profit is out of the question, the alleged necessity has not been outgrown, of employing the profit-seeking contractor. The "ancient" system is still followed which places its premium on self-seeking, thus making inevitably for immorality. It is only in so far as the "modern" system is thus smirched by its contact with the "ancient" system, that "graft" exists. The "modern" system is pure. Governments approach respectability in proportion as they assume new and greater public service functions.

The inevitable transition, from the "ancient" to the "modern" system, is being brought about by the irresistible push of universal demand, the selfish demand for better service than the "ancient" system can give. It is significant that this relatively "modern" discussion on highway transportation has dealt with the more "modern" highway system, under which a public servant, caught playing the "business man" and making a profit out of his position, would be disgraced forever.

Note these two illustrations, one taken from the "ancient" the other from the "modern" system, the two showing the contrast between the moral standards of the two systems:

(1).—During this discussion, it has been stated that, under the "ancient" system, it is considered not at all irregular for a railroad line, in competition with a water line, to reduce its rates to the losing point, and to keep them there until it has killed off its water competitor, whereupon it proceeds to charge "all the traffic will bear".

(2).—Contrast this with the attitude of the Pennsylvania Highway Administration, as outlined by Mr. Hilts, and its attitude toward the contractor. Far from taking advantage of the contractor's ignorance of conditions, it strives to keep him out of difficulty, knowing that, in difficulty, he cannot serve efficiently.

Eugene W. Stern,† M. Am. Soc. C. E.—In connection with the question of Highway Transportation it may be in order to speak of the imperative necessity of having only highly capable men in responsible charge of highways.

* Philadelphia, Pa.

† Cons. Engr., New York City.

Too much cannot be said to the public for their own good in this regard. Men of only the highest qualifications should be employed, and such men cannot be retained unless they are paid adequate salaries and are freed from political subserviency.

For years, the speaker has noticed that the lack of intelligent vision and foresight on the part of chiefs of various highway bureaus has been responsible for the construction of highways utterly inadequate for the traffic and hence extremely expensive to the taxpayer. He has seen roads of an inferior type built to carry heavy and ever-increasing traffic, which should have been built to a standard almost equal to that of a high type of city pavement. On account of the vast sums of money now being expended in highway construction and which will increase as years go on, it is in the power of the men chosen to head highway departments, by poor judgment, by improper selection of types of roads, by incompetent and negligent supervision, to inflict on present and future generations, enormous annual excess charges for upkeep, over and above what proper construction, etc., would have warranted.

The failure to make the right decision in the selection of type of roads by those who had the power to do so, is causing losses of millions of dollars a year to the taxpayers of the State of New York. The speaker does not blame the present, nor the past administrations, nor any particular administration, for this state of affairs. The motor vehicle had to be accommodated, and provision was not properly made for it in the writing of the specification for many roads, on which enormous sums for annual maintenance charges are now being paid.

Lack of vision is often shown by highway commissioners in neglecting to improve the alignment, gradients, etc., of old roads. A 16-ft. roadway is known to be not wide enough for safety on an important highway. Why continue to build them? Why build roadways 16 ft. wide on curves, when they should be at least 26 or 30 ft. wide, to safeguard life? An old highway built for horse traffic a century ago, for instance, is being improved with a hard surface for motor vehicle traffic. Why is the location of this road not changed, the alignment corrected, the curves made easier, the gradients improved? Lack of vision and intelligence on the part of those who are chosen to safeguard the interests of the people in road construction, are responsible for these deficiencies.

The speaker will mention a case in point: The main thoroughfare called the Albany Post Road, which leads north from New York City along the east bank of the Hudson River through Tarrytown and Peekskill to Albany, has many errors in location and construction. In this regard it is the worst that the speaker has ever seen on any stretch of important road. He has been over many miles of roads in France and has never seen a poorer piece of location, even on the unimportant Communal roads (comparable to our town roads). Many defects of alignment, curvature, and grades could have been eliminated when the road was being changed for motor traffic. There are many places dangerous to life. On a main thoroughfare on which the traffic is enormous, there should never be such names as "Dead Man's Curve", etc.

If the speaker has made some impression, it is hoped that it may have the effect of bringing to the minds of those responsible for the selection of men to head highway bureaus, the importance of having only the highest and most competent type of men; that they must be allowed practically a free hand and not be interfered with by politicians; and that, unless this is done, the waste of money due to deficiencies in construction and maintenance of highways, in this coming generation, will run into enormous sums annually.

An unparalleled era of road construction in the history of engineering operations is now being entered. It is up to the Engineering Profession to design, construct, and maintain roads efficiently and economically to take care of motor vehicle traffic.

The Engineering Profession has never yet failed in its service to the public if given a proper chance, and it will make good if the taxpayers appreciate its services at a proper value.

HENRY GOLDMARK,* M. AM. SOC. C. E.—The speaker wishes to say a few words on the condition of highway bridges as distinct from the highways themselves. He is led to do so more especially by a recent personal experience, which may be worth recounting at this time, although it has been referred to in a recent letter to *Engineering News-Record.*

This experience is connected with one of the main highways in the Adirondacks over which the speaker has had occasion to travel for more than thirty years. As the amount of traffic and the weight of the vehicles have increased, the road has been gradually improved so that now it has an excellent macadamized roadbed, well fitted for the present heavy traffic, since the latter is limited to a few weeks in the summer.

No similar systematic improvement has been made in the numerous bridges along the road although many of the bridges are quite old and their reconstruction, from the standpoint of safety, is of even greater importance. Near its upper end, this road crosses the Ausable River on a 75-ft. pin-connected steel span, about 30 years old, which has very light sections and poor details. The bridge would hardly be fit to carry present-day traffic, even if it were in perfect condition. Five or six years ago, one of the abutments was undermined by a flood, allowing the bridge to drop about 15 ft. on the rock bottom. The steelwork was badly injured, but was straightened as well as possible and re-erected on the new masonry. It is, however, in bad condition. The eyebars, in many panels, are so bent that one of the two bars carries the whole stress; but, worse still, the trusses are badly out of plumb and twisted, the top of one end post overhanging by as much as 12 in. in a height of 8 ft. As the bridge is a pony span with no lateral top bracing and no sway bracing to keep the top chords from buckling sidewise, the latter form a very crooked compression member nearly 80 ft. long under a fairly heavy stress. A truss in this condition, of course, would be very unsafe, even if the several members had ample cross-sections.

The bridge has remained about as described for the past five years. About three years ago, its condition was pointed out to many prominent residents

* Cons. Engr., New York City.

and summer visitors, who after a moment's inspection seemed, without exception, satisfied that "something should be done at once". However, apart from fastening one of the end posts to a tree with a piece of telegraph wire, no repairs have been made to the present time. As a matter of fact, the span could be made reasonably safe for $750, but it is doubtful whether public opinion will be intelligent enough and strong enough to insist on any action in the matter.

This incident would hardly be worthy of mention, but for the fact that in New York State at least there is no means of getting a bridge of this kind repaired except through the pressure of public opinion. A former law instructed the State Engineer to have highway bridges which are reported as dangerous, inspected by his staff and if unsafe closed to traffic. It is understood that this law was repealed some years ago through the influence of country members of the Legislature to avoid expensive bridge repairs. Outside of the larger cities, the matter rests entirely with local bodies.

It is understood that, in many other States, conditions are better, but, on the average, highway bridges the country over are weak under modern loads. Conditions have changed; a generation ago the traffic consisted mainly of light vehicles belonging to local residents. At present, heavy automobiles go even into remote districts. The older bridges were suitable for carrying the lighter loads. It is hardly fair, and certainly not practicable, to expect the poorer country districts to stand the expense of renewing immediately all bridges not fully up to modern standards. They are, on the whole, doing as much as can be expected in replacing the old spans with stronger ones as needed. To eliminate all dangerous structures within a reasonable time, it seems equitable that the cost should fall, in large part, on a more extended political district than the town or county. The inspection of existing bridges at proper intervals and the approval of plans for new ones should come under some proper State authority.

Engineers cannot avoid the responsibility for the strength of bridges and similar structures, since, as pointed out by *Engineering News-Record,* in a recent editorial, the public looks to them for instruction and, if necessary, for action in such matters. Some action should be taken by the Society and other influential bodies, so that the public may feel assured they are not risking their lives when passing over the highway bridges throughout the land.

H. W. Brown,* Jun. Am. Soc. C. E.—Several of the speakers have emphasized the need for training inspectors and others connected with highway work. Some have suggested that European schools, or methods, trained a man better than American schools or methods. One discussor has even gone so far as to state that, of all the highways he saw in France, not one was incorrectly located.

It was the speaker's good fortune while with the Army in France, to attend L'Ecole Nationale des Ponts et Chaussées, otherwise known as the National School of Bridges and Highways, for a few months after the Armistice. Even though a graduate of, and, later, an instructor in, one of the foremost schools of the United States, the speaker found that he had much to learn, both in

* Engr., The Housing Co., Boston, Mass.

technique and in methods of teaching, from the French system. Perhaps a brief résumé of his observations of the working of this system will not be out of place here.

The principal engineering work in France is controlled by a corps known as "Ingénieurs des Ponts et Chaussées". These engineers are chosen from the highest graduates of L'Ecole Polytechnique, a school which corresponds somewhat to American colleges and scientific schools.

With the rank of "Elèves Ingénieurs", these men are sent by the Government to L'Ecole des Ponts et Chaussées for two years. The instruction at this school is given by men high in the active practice of their particular branch of the profession, and amounts to considerably more than that given at the average American school, because an attempt is made to start the new students with the benefit of the experience of the older men in analyzing the general, as well as the specific, elements of the problems which they will be likely to encounter. Little attention is paid to the method of analyzing stresses and strains—the students are well trained in mathematics and mechanics before entering the higher courses—but great stress is laid on methods which many practicing engineers in the United States would class among their professional secrets—things that it is claimed can only be learned by experience. The result is a thoroughly educated engineer who starts out with the combined experience of his predecessors as his foundation.

The uniform standard of excellence which these engineers have been able to maintain in all their work, has won for them great public esteem and confidence. That this confidence is richly deserved, has been implied by at least one of the speakers, and it is the consensus of opinion of the majority of careful observers of French engineering practice.

These few points are mentioned because of the feeling that Americans, as engineers, ought to investigate the work which other nations have done, in order to better their own methods. Surely engineers with the experience of the men who have discussed this subject, could investigate the methods the French have been developing since the time of Louis XIV, to help Americans solve in the best possible manner their problem, which, very evidently, is a pertinent one.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

PROGRESS REPORT OF THE SPECIAL COMMITTEE TO CODIFY PRESENT PRACTICE ON THE BEARING VALUE OF SOILS FOR FOUNDATIONS, ETC.*

To the American Society of Civil Engineers:

The Special Committee appointed to investigate soils in relation to their bearing capacity and other inherent qualities, respectfully submits this, the seventh, Progress Report of its work.

During 1921, three meetings were held, the minutes of which have been reported to the Society. At the meeting of May 13th, 1921, it was stated that the Board of Direction had granted the Committee an appropriation of $2 000, the greater part of which was assigned to the Iowa State College for experimentation and the remainder to the work of sub-committees. Your Committee formally expressed its appreciation for this encouragement, the first received for several years, and now acknowledges the assistance of this real support. Some of the results are submitted herewith; others will follow in future reports if continuation of the work meets with approval.

Your Committee presents herewith the attached reports as appendices without comment, and looks forward to discussion by members of the Society.

Appendix I refers to the compression or settlement of soil under test or from the load transmitted by structures. The report of your Committee for 1920, Appendix V, referred to the importance of settlement on the bearing capacity of soils, and of the stability of structures supported on soils, etc. It also stated that it was proposed to submit to the membership, a blank form for recording observed settlements and loads, with the hope that such records would be submitted to your Committee for compilation.

During 1921, such a form of questionnaire, with an explanatory letter, was sent to the entire membership of the Society. The results have been disappointing, because the number of replies received to date is too small to enable any definite results or tables to be developed that might be useful as a guide for engineering design. From the answers received, it has been ascertained that the large type of practical soil-testing apparatus, sub-

* Presented to the Annual Meeting, January 18th, 1922. Previous Progress Reports of this Special Committee have been published in *Proceedings*, Am. Soc. C. E. (Papers and Discussions), February, 1915, p. 491; March, 1916, p. 343; August, 1917, p. 1171; August, 1920, p. 905, and February, 1921, p. 9.

mitted by your Committee in its report for 1919, has been used with most gratifying results. The details of the tests made with the apparatus are included in Appendix I.

Since results from the use of the apparatus submitted by the Committee appear to be satisfactory, the adoption by engineers of its principle for practical field determination of the bearing capacity of soils is suggested. It is hoped that by making tests by a uniform method, and classifying the soils so tested, in the uniform manner suggested by your Committee in previous reports, sufficient data may be obtained in such a form as to enable one to predict, within reasonable limits, the amount of compression of the soil from the application of a definite load. The questionnaire was in a form which would permit members to submit information so obtained, at any time in the future, and thus greatly assist your Committee in the collection of the data desired.

Appendix II is condensed from a review of present design methods, made quite independently of your Committee by Eugene E. Halmos, M. Am. Soc. C. E., and confirms previous statements of the Committee. Your Committee has never lost sight of the need for the immediate revision of the existing formulas for use in connection with fine-grained soils.

The demand for additional experimentation which was so commendably presented by William Cain, M. Am. Soc. C. E., in his paper on "Cohesion in Earth: The Need for Comprehensive Experimentation to Determine the Coefficients of Cohesion",* is further emphasized here. Until these data are available, the task of your Committee will not be complete.

Appendix III is an incomplete compilation from recent scientific literature relating to clay, in which, as far as possible, the extracts have been limited to the language of the authors. The Appendix is supplemented by a bibliography and is submitted as information.

In the last report of your Committee, sufficient information was at hand to justify urging attention to the colloidal substance of clay and the influence of the colloidal state of clay on its physical characteristics. Recently, your Committee has received supplemental confirmation from the paper by Messrs. Moore, Fry, and Middleton, Soil Physicists, United States Department of Agriculture, which is included in this Appendix.

The paucity of knowledge as to colloids in the literature of Engineering, has led to the search for data in the Governmental and other publications of the related technical industry of the clay worker, from which source Appendix III has been largely compiled.

Regarding the properties of clays, your Committee would point out that two concepts of the colloidal state of clay have been presented: (1) That due to the presence of a colloidal substance in the clay; and (2), that due merely to the existence of solid particles in a state of extremely fine subdivision (suspensions).

Regarding the first concept, the consensus of opinion of investigators is decidedly in favor of the presence of a colloidal substance. Although it is known that the percentage of colloid material is very small, the significance

* *Transactions*, Am. Soc. C. E., Vol. LXXX (1916), p. 1315.

of its physical influence is quite evident. However, certain clays and fine-grained glacial soils, in which there is an absence or only a trace of colloidal material, would lead to the consideration of the colloidal state as a physical property rather than a peculiar substance. Much further study must be given to this problem.

References to other properties of clays are given as they affect the clay industry. The information, however, should be of use, by assisting the engineer to interpret his problems in clay soils.

Appendix IV is a contribution by J. H. Griffith, M. Am. Soc. C. E., acting under the direction of Anson Marston, M. Am. Soc. C. E., of Iowa State College, on the strength of clays as they occur in their natural position and without disturbance.

The subject is considered as follows: (1) Plan of investigation; (2) tensile tests; (3) shearing tests; and (4) compression tests. Although the investigation is incomplete and will be continued, the report is presented as information, through the courtesy of Dean Marston. The results developed are edifying and indicate that further experimentation is needed.

It will be remembered that soils, as they occur in Nature, differ from artificial or re-worked soils in many properties, including density and structure. For instance, the difference in properties between the natural or undisturbed soil under a retaining wall and the artificial back-filling is obvious, and these properties will continue to have the attention of your Committee.

The present popular demand for the improvement of country roads has brought forcibly to the front problems related to the foundations of the surface pavement in supporting rolling loads.

Since the work of your Committee is directly connected with this problem, the studies in its progress reports can be utilized to advantage, if so desired. It is suggested to those making independent investigations that the use of your Committee's classification, definitions, and laboratory procedure, together with other information furnished, will facilitate future co-ordination. With or without the active participation of your Committee, this co-operation would prove an economic advantage in National progress in this problem.

Your Committee is pleased to be able to record the cordial response of U. S. Bureau of Public Roads, Mr. J. H. MacDonald, Director, in the desire to co-operate, and here acknowledges his courtesy and assistance rendered through correspondence and the report of A. T. Goldbeck, Assoc. M. Am. Soc. C. E., on present laboratory procedure (Appendix V).

This Appendix is particularly interesting in the study of the colloidal substance of clay, which has recently occupied the attention of the Bureau. The adsorption test was developed in its laboratory by Dr. E. C. E. Lord, of the Bureau, and is intended to facilitate testing and give simple and quick results to meet the requirements of the engineer.

Under an arrangement with Harry W. Boetzkes, M. Am. Soc. C. E., a translation of Résal was made available for the use of the Committee. He also submitted a scheme for determining pressures.

Acknowledgment for furnishing data is extended to those members of the Society who replied to the questionnaire, and to the published discussions

of past progress reports by Mr. A. L. Bell,* and F. N. Menefee,† Assoc. M. Am. Soc. C. E.

Future progress in the work of your Committee is obviously dependent on experimentation. Since the essentials of the problem have been indicated, it will be the endeavor of the Committee to arrange a suitable program for tests. An invitation will be extended to all those institutions sufficiently interested to co-operate.

It is the hope of your Committee to be able to put into final form during 1922, a report based on the data secured and on present practice in the bearing capacity of soils for foundations, and, with permission, to continue the study of the physics of soils.

Respectfully submitted,

Robert A. Cummings,
Chairman.

Committee:

Robert A. Cummings, *Chairman,*
Walter J. Douglas, *Secretary,*
E. G. Haines,
Allen Hazen,
J. C. Meem.

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* Pamphlet, Am. Soc. C. E., May, 1921.
† Pamphlet, Am. Soc. C. E., January, 1921.

APPENDIX I

REPORT ON SETTLEMENT

The Sub-Committee appointed at the meeting of the Committee on June 6th, 1921, to prepare and submit to the membership of the Society a circular letter and questionnaire soliciting records of settlement of actual structures, and of compression of the soil under test loads, reports as follows.

Such a circular letter and questionnaire were prepared by the Sub-Committee and sent by the Acting Secretary of the Society, in printed form, to 10 107 members of the Society, under date of August 3d, 1921. To date, replies have been received from only 65 members. Of these, 2 members returned the questionnaire and circular letter without notes or accompanying letter; 2 members replied they had no information to submit; 21 members returned their information on the printed questionnaire, instead of on blue prints as requested, which precludes their submitting additional information at a later date, in the form desired; 18 submitted information of other kinds, or in other form, than requested; and only 22 members furnished information of the kind and in the form requested by the Sub-Committee.

The replies received came from points as far away as Australia, India, and Hawaii, although most of them were from points within the United States. The character of the information submitted covered a variety of soils and tests made in a number of different ways. It is apparent, therefore, that the information obtained in response to the questionnaire is neither sufficient in quantity nor of a type susceptible of classification to show the probable amount of compression of different classes of soils under different amounts of loading and, in that respect, the results from the questionnaire may be considered a failure.

Indirectly, however, the questionnaire has proved of great value, as it has revealed the fact that the large type of practical soil-testing apparatus devised by the Committee, and submitted to the Society as part of the Committee's report for 1919, has actually been used in practice, with very satisfactory results.

Frank A. Johnson, Assoc. M. Am. Soc. C. E., Assistant Engineer with H. J. Brunnier, M. Am. Soc. C. E., of San Francisco, Calif., reports that the Committee's recommended device was used for tests at the site of the Standard Oil Office Building, in San Francisco, with satisfactory results. On Plate VII is shown the soil compression, loading, etc., and Figs. 1, 2, and 3 show the apparatus in position.

A. H. Dimock, M. Am. Soc. C. E., City Engineer of Seattle, Wash., by F. A. Rapp, M. Am. Soc. C. E., Bridge Engineer, reports that the Committee's device was used by that Department also, with satisfactory results.

In both the cases reported, practically no modification was made in the Committee's design shown on Plates VIII and IX, other than to substitute an ordinary screw-jack, for the one recommended by the Committee, at the top of the compression post. These being the first two cases, as far as known to the Committee, where the recommended device has been used. Further information was requested from both Mr. Johnson and Mr. Dimock.

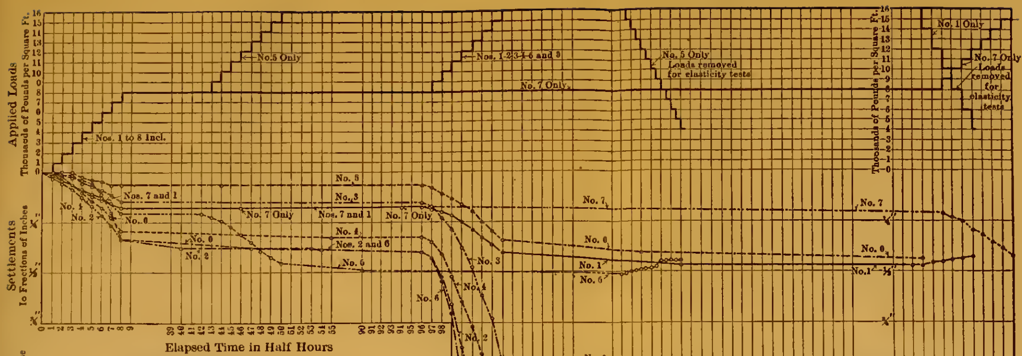
In reply to certain categorical questions, Mr. Johnson states that the recording device used was the same type recommended by the Committee, with a magnification of 1 to 5. Mr. Johnson, however, used two record boards at right angles to each other and took the average of the readings as the true settlement. This was done to nullify the effect of any possible tilting of the compression post, but Mr. Johnson states that there was little difference between the reading of the two charts. It is further stated that there was no decided tendency for the surrounding soil to rise around the edge of the compression plate, although several of the tests were made under water, but, in that case, one had to be guided by the sense of touch in determining the point. The principle of the apparatus proved to be correct and simple to apply. Although sand was used in the hopper, Mr. Johnson believes that water would be better and simpler. Great care had to be taken in applying the sand increment, because a light jar of the hopper was transmitted with greater intensity to the post. When loads were released, to obtain elasticity tests, all the recorded rise or recovery was due to the expansive action of the soil, because, the record on the recording charts being determined solely by the position of the compression post, it was independent of any distortion of the apparatus above.

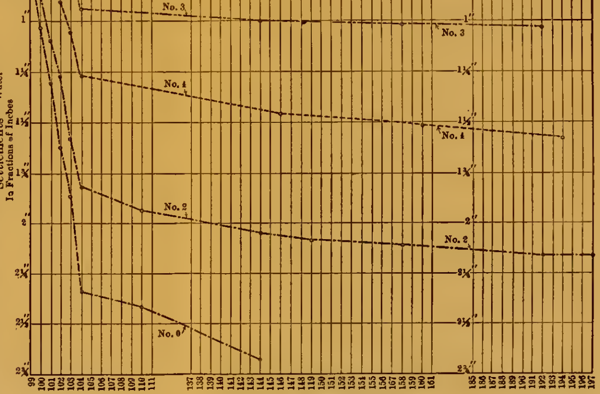
Mr. Johnson further states that the use of burlap beneath the compression plate and tile, in the case of set soil, as suggested by the Committee in its report for 1920, is believed to be a good suggestion, as it would tend to resist the natural tendency for the material to squeeze out from under the compression plate. Finally, it is stated that the total cost of conducting the eight tests was only $321, which included the cost of the materials and the time of one carpenter and two laborers for the entire period of the tests.

In reply to similar categorical questions in regard to the use of the device, Mr. Dimock states, in substance, that no substantial modifications were made in the Committee's recommended design; that the recommended recording device was used with a magnification five times the amount of settlement; that the device was both definite and quite delicate in operation; that he would suggest no changes in the design; that it was used for two tests, within 50 ft. of each other, and found to be quite easily dismantled and set up again by three men; that sand was used in the weight-carrying box; that the cost of the machine, including all labor and material, was only $106; and that the total cost of making the first test, including the machine, was only $162, exclusive of the cost of engineering supervision.

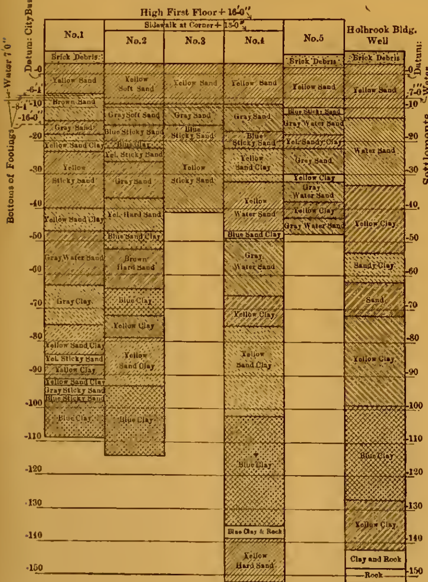
An examination of Plate VII, which shows the results from the eight tests submitted by Mr. Johnson, is most interesting and indicates the sensitiveness of the apparatus, considering its capacity and portability. The curves, showing settlement under the application of load, although differing in the amount of settlement, are uniform in character and reveal the elastic character of the soil, both while applying the lighter loads and, more clearly, in the case of two tests where, after reaching a considerable amount of loading, a part of the load was removed. The elastic recovery of the soil in these two cases was clearly revealed by the recording device. The breaking down, or sudden

PROGRESS REPORT OF
SPECIAL COMMITTEE TO CODIFY
PRESENT PRACTICE ON THE BEARING VALUE
OF SOILS FOR FOUNDATIONS, ETC.

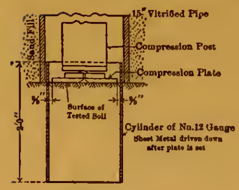




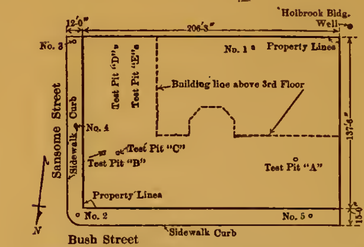
LOG OF SOIL BEARING TESTS



LOG OF BORINGS



DETAIL
SHOWING SHEET METAL CYLINDER
USED IN TESTS NO. 5-6-7 AND 8



PLAN SHOWING LOCATION OF BORINGS AND TEST PITS

● Denotes locations of Borings
▫ Denotes locations of Test Pits

NOTES: All Tests made as suggested by "The Special Committee" to Codify Present Practice on the Bearing Value of Soils for Foundations, in its progress report to the American Society of Civil Engineers; Proceeding A.S.C.E. August-1920, Page 906, except as shown and noted.

NOTES ON SOIL BEARING TESTS

No. 1— In Test Pit "A". The bottom of the Compression Plate at elevation —5'6" below Datum—about 1'0" above water.

No. 2— In Test Pit "B". The bottom of the Compression Plate at elevation —8'0" below Datum—about 1'0" below water.

No. 3— In Test Pit "C". The bottom of the Compression Plate at elevation —6'0" below Datum—about 1'0" above water.

No. 4— In Test Pit "C". The bottom of the Compression Plate at elevation —7'0" below Datum—about 0" below water.

No. 5— In Test Pit "C". The bottom of the Compression Plate at elevation —7'0" below Datum—about 0" below water. Plate enclosed in sheet metal cylinder

No. 6— In Test Pit "D". The bottom of the Compression Plate at elevation —5'0" below Datum—about 1'3" above water. Plate enclosed in sheet metal cylinder.

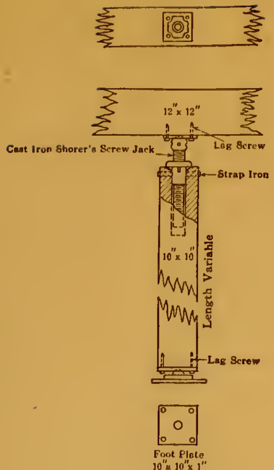
No. 7— In Test Pit "D". The bottom of the Compression Plate at elevation —7'0" below Datum—about 9" below water. Plate enclosed in sheet metal cylinder.

No. 8— In Test Pit "E". The bottom of the Compression Plate at elevation —5'9" below Datum—about 1'3" above water. Plate enclosed in sheet metal cylinder.

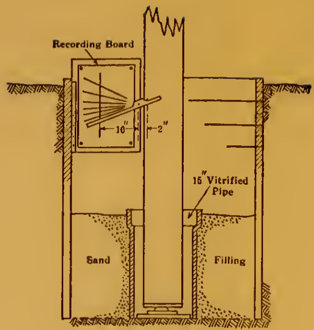
Test No. 8 made as check on Test No. 6.

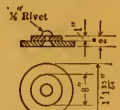
Loads added in 1000 pound increments.

PLATE VIII.
PAPERS, AM. SOC. C. E.
MARCH, 1922.
PROGRESS REPORT OF
SPECIAL COMMITTEE TO CODIFY
PRESENT PRACTICE ON THE BEARING VALUE
OF SOILS FOR FOUNDATIONS, ETC.

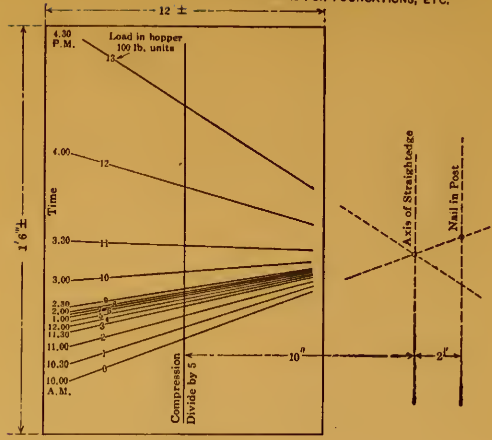


COMPRESSION POST

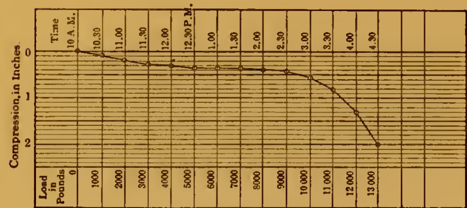




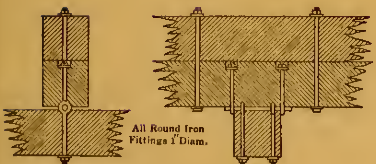
COMPRESSION PLATE



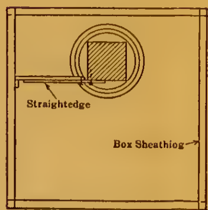
FIELD RECORD



COMPRESSION DIAGRAM
(Typical, for uniform application of load.)



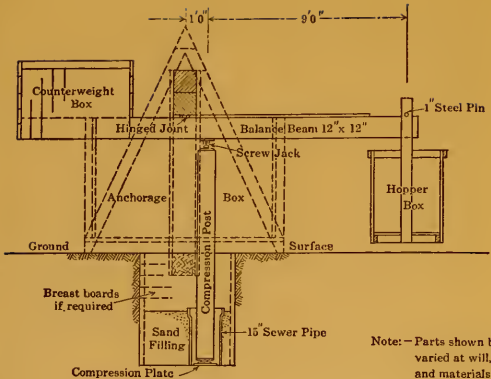
HINGE FITTINGS



RECORDING DEVICE

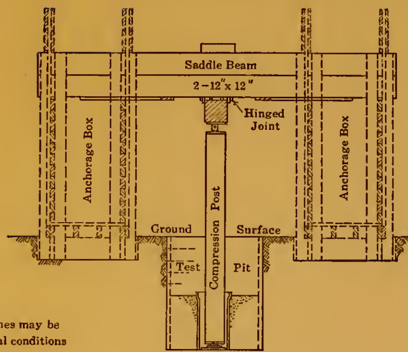
PROPOSED STANDARD LARGE TYPE
OF
LOAD TESTING APPARATUS FOR SOILS

PLATE IX.
PAPERS, AM. SOC. C. E.
MARCH, 1922.
PROGRESS REPORT OF
SPECIAL COMMITTEE TO CODIFY
PRESENT PRACTICE ON THE BEARING
VALUE OF SOILS FOR FOUNDATIONS, ETC.

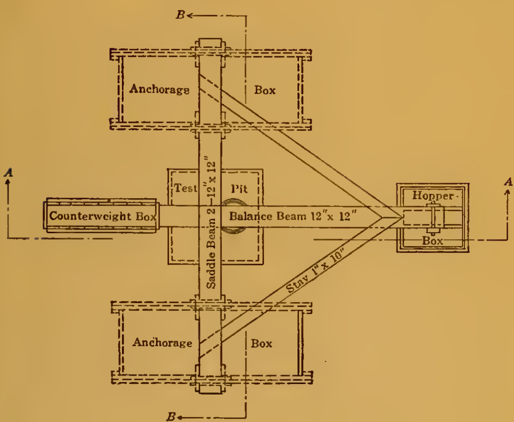


SECTION *A-A*

Note:—Parts shown by dotted lines may be varied at will, to suit local conditions and materials available.



SECTION *B-B*



PLAN

The essential features of this device are as follows: A bearing plate, compression post, adjusting screw, balance beam, ballast hopper, counterweight, saddle beam with anchorages, and the necessary recording device. They should be used in the following manner:

After erecting the anchorage boxes and saddle beam, the boxes should be filled and the balance beam put in position and balanced, with the hopper in place, by filling the counterweight box. After excavating a test pit (using breasting boards, if necessary), the bottom should be carefully leveled, and the bearing plate placed in position by plumbing down from the plate on the balance beam. The section of sewer pipe should then be placed and carefully backfilled. The compression post may then be placed, the screw adjusted, and the recording device attached. This consists of a board, on which is tacked a sheet of paper, and a light straightedge hinged near the edge of the board. A vertical line is ruled on the paper, at some fixed ratio of the distance from the axis of the straightedge to a nail driven in the compression post. At the start, and as weight is placed in the hopper, lines should be drawn along the straightedge and the time and weight recorded. The balance beam should be kept level, as the post is depressed, by means of the adjusting screw.

The hopper may be calibrated and a scale attached for direct reading of the weight. Either dry sand or water may be used, and provision made near the bottom of the hopper for drawing them off.

All contact points should be coated with heavy grease.

PROPOSED STANDARD LARGE TYPE
OF
LOAD TESTING APPARATUS FOR SOILS

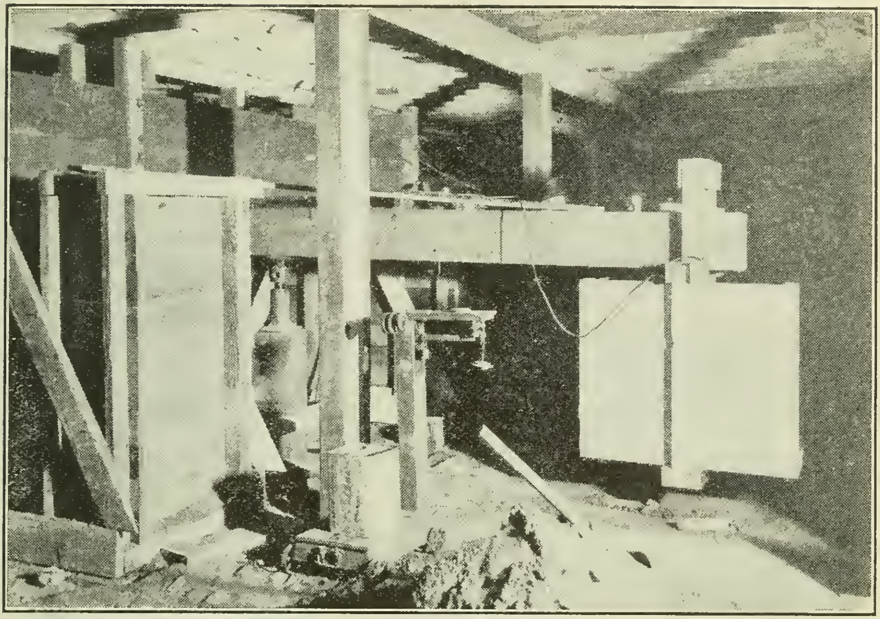


FIG. 1.—SOIL TESTING APPARATUS IN POSITION.

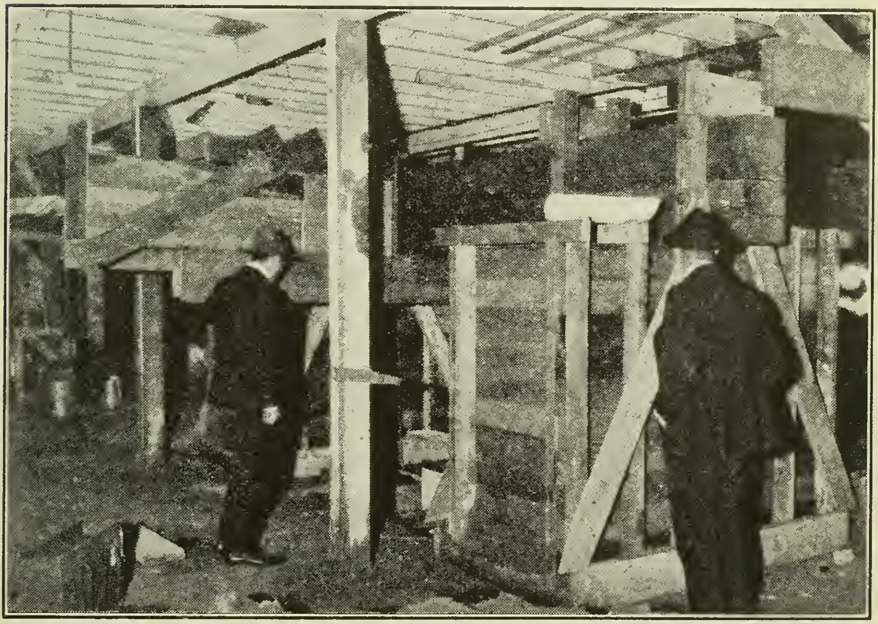


FIG. 2.—SOIL TESTING APPARATUS IN POSITION.

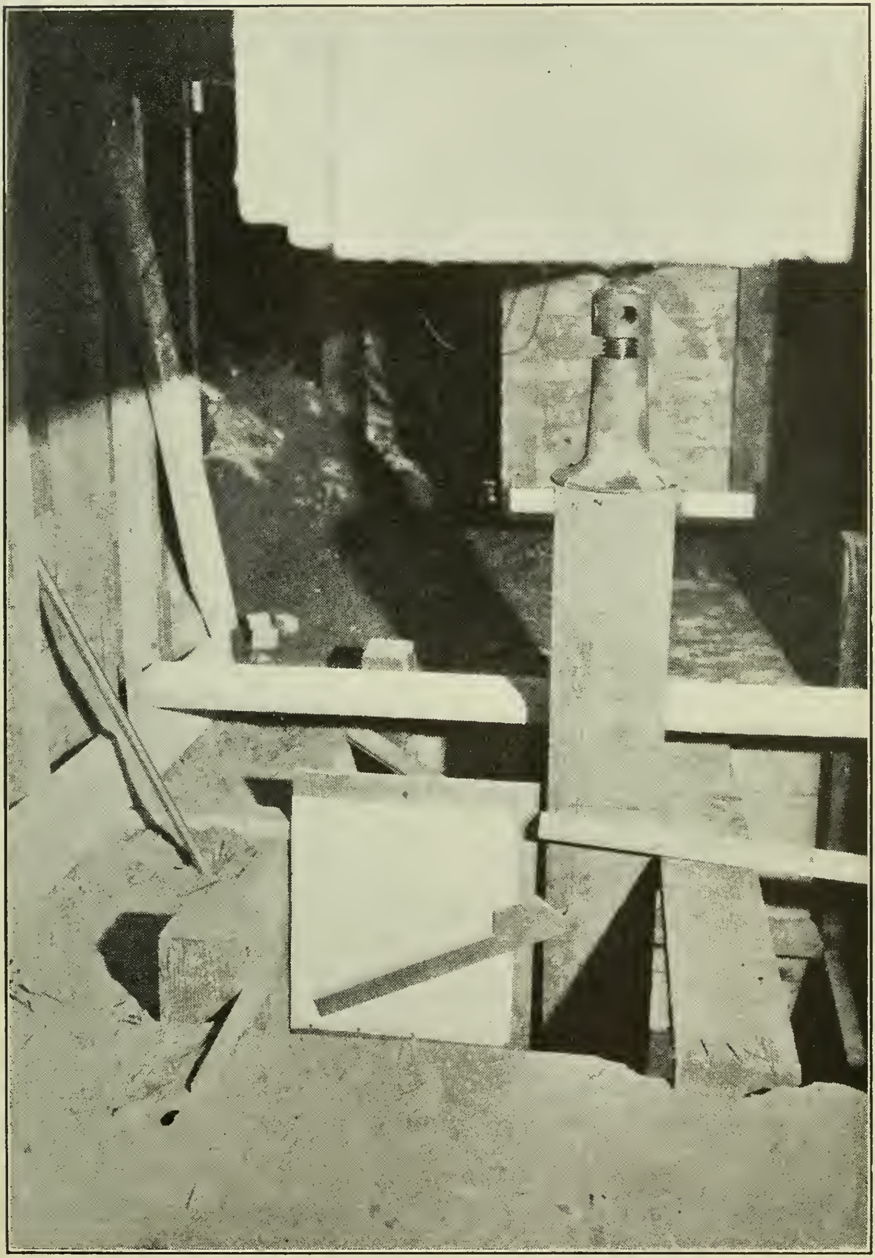


FIG. 3.—SOIL TESTING APPARATUS IN POSITION.

loss of supporting capacity, of the soil under excessive loads, is also clearly shown.

In four of the tests, both above and below water, the soil-testing plate was surrounded with a thin shell of metal. In regard to this, Mr. Johnson states that, at the time the tests were conducted, some preliminary studies of the foundation for this building had been made, the conclusion being reached that because of the light soil pressure to be used, the foundation would require a reinforced concrete mat under the entire high part of the building. It was also thought necessary to use steel sheet-piling around the outside, to prevent undermining in case of future excavations near-by. As the use of this sheet-piling was deemed to create a condition somewhat analogous to confining the soil around the compression plate of the testing device, it was decided to force a sheet metal cylinder over the compression plate in some of the tests. As can be seen from the records of the tests, nothing definite was proved. It is thought probable that the compression was carried through the material in the cylinder as if it were a continuation of the compression plate.

Aside from incorrect or indefinite classification of the soil, much of the present uncertainty, as to bearing capacity of different soils, is due to the fact that such tests as are recorded were made in a great variety of ways, often with crude devices and lacking sensitiveness, which precludes the possibility of measuring and recording the smaller compressions and elastic reactions under relatively high loads. Tests made in such a manner are practically valueless, for it should be understood that the bearing capacity of soil is determined, not by the settlement produced by a heavy load, for then displacement of the grains and failure of the soil have already taken place, and, when the settlement stops, the soil has a factor of safety of only 1 +; but rather by the elastic reaction of the soil and the measure of compression under relatively light loads, which is true of other materials used in engineering construction.

However, it is not intended to preclude, where practicable, the making of compression tests of soil to determine its ultimate bearing capacity as well as its elasticity, and its settlement under varying loads should be known. The practical value to the engineer of knowing approximately what the expected settlement of a soil may be under varying loads is inestimable.

The high character of the results reported by both Mr. Johnson and Mr. Dimock, the low cost of constructing and operating the machine and its sensitiveness to variations of loading and compression—especially in view of its large capacity—would seem to justify the recommendation to the Society of the general use of this apparatus for conducting field tests of the bearing capacity of soil. The apparatus overcomes many of the defects common to most of those used for such tests, among which may be mentioned the tilting of the post, bringing unequal bearing on the top of the compression area; the large platform area necessary in most devices to secure sufficient load for the test; the friction developed in the stays and bracing necessary to balance such a large load; the lack of ready portability in the large platforms generally used; and, finally, the lack of accuracy in recording settlement by piano wires or any other means where the measurement depends on the eye.

The nature of the apparatus is such that it is readily portable, as shown in both cases where it has been used, where it was handled by three men; and the cost of the machine, including all materials and labor, is, also, relatively very low.

Your Sub-Committee, therefore, recommends the general adoption of this apparatus for tests of direct bearing capacity of soils, which may be made in the future.

APPENDIX II

REVIEW OF PRESENT METHODS

Although a compilation and simultaneous publication in proper form of all the existing theoretical studies and formulas, and of all the published tests on earth pressure on retaining walls, would be interesting, it is not apparent that a new formula digested from the information so obtained and recommended for use would be any better than the theories and the test results on which such new formula was built.

As is well known, all the earth pressure theories evolved to the present time are open to serious criticism. This statement equally applies to the older (Coulomb, Rankine) theories which are based on the assumption of the incompressibility and constant internal friction of the cohesionless granular soil, as to the newer (Boussinesq, Saint-Venant, Levy, Forchheimer, Skibinsky, etc.) theories considering the elasticity of soils, and to those (Resal, Cain, etc.) including the effect of cohesion. All these theories are objectionable chiefly on account of their common assumption of a rigid, unyielding structure and of a uniform backing material, both of which assumptions are far from the actual conditions encountered in practice. Consideration of the displacement of the structure, together with a varying consistency of back-filling, however, would introduce such difficulties in the rational treatment of the subject, which, at the present status of mathematical science, seem to be insurmountable.

The published results of tests made to determine the magnitude of the lateral pressure and other characteristics of soil, are of even less convincing value than some of the previously mentioned rational formulas. All these tests, as far as is known, were made on a small scale, with a few selected and carefully placed materials, not even approaching the conditions under which retaining walls actually sustain pressure.

On the other hand, it is unquestionably true that retaining walls designed on many of the theories mentioned and using the generally accepted values of friction angles for the backing material, proved to be successful. If failure occurred, it could be invariably traced to foundation troubles or, in case of clay material, to causes other than the insufficient strength or stability of the wall itself.

It would not be wise, therefore, on the basis of existing information, to recommend a formula which would give a stronger wall than Rankine's, or to recommend another formula resulting in a thinner wall.

It appears that the only way to settle the one and one-half century old problem of retaining walls is to base the theory and the determination of the constants on experiments made on a large scale, with models ranging from 5 to 25 ft. in height, and using methods of back-filling similar to those used in the field. The largest possible variation of back-filling material should be tested if the results are to be of help to the designer. This, of course, is a difficult problem to solve, as it involves the measurement of the "earth pressure at rest", but a great deal of work with a view of devising a testing apparatus measuring the thrust of earth on retaining walls has been already done by Professor Müller-Breslau and others.

With regard to the bearing capacity of soils under foundations, the proper measure of such value is the settlement of the soil under loads. The aim of the Committee should be to obtain a large number of settlement diagrams for soils of various consistencies and stratification. Such diagrams, if the tested soils are accurately described with reference to the classification proposed in the Progress Report of 1916, will prove invaluable for the practising engineer.

It is believed that the collection of experimental data along uniform lines of procedure would be of the greatest benefit for both the practising and the research engineer, and that if the Committee should do nothing more than compile such data in large numbers, it would deserve the gratitude of the Profession.

The laboratory tests which have been made in the past and which are now in progress are by no means valueless from the point of view of the practical engineer. There are certain structures such as grain, sand, and coal-bins, where the uniform consistency of the material justifies the use of rational formulas, and this is true in some cases of retaining walls and foundations. Such formulas for some simpler cases have already been derived giving at least a true qualitative indication of the distribution of stress in homogeneous soils. With the elastic and frictional constants determined by laboratory experiments, these formulas will become at once practically applicable for the limited field in which the basic assumptions approximately hold. However, for the larger field of retaining walls, foundations, and piles, it appears that the way by which reliable results can be obtained is in testing *in situ*.

APPENDIX III

COLLOIDAL STATE OF CLAY

It is the purpose in this Appendix to present the result of a preliminary search of scientific literature relating to clays.

Definition of Clay

Clays may be defined as adventitious mixtures of inert minerals such as sand and a complex compound possessing colloidal properties such as silicates of aluminum, iron, the alkalies, and the alkaline soils. Some clays are not wholly colloidal but may resemble a mass of mineral particles partly covered with a colloidal substance. The quartz grains and mica present in clays are

seldom covered with the colloidal substance. When the combination of the granular particles and colloidal substance in suitable proportions is moistened with water, plasticity is developed. An excessive proportion of sand will produce a sandy clay, and if the colloidal substance is in excess, the clay is plastic.

Colloids in Clay

The existence of colloidal substance in clays was established nearly fifty years ago by Schloesing. More recently, Rohland has presented a systematic exposition on the colloidal properties of clays, which has been generally recognized.

Colloids exist: (1) As homogeneous suspension in a liquid, called a "sol", and possess the essential properties of liquids; (2) as a continuous jelly with pore walls (and pores) filled with a liquid called a "gel". Solids are included under (2) as a limiting case. The sol or gel is named by a prefix according to the liquid with which it is associated, as hydrosol, alcosol, etc.

By analogy with the systems of coarser particles, the solid-particle sols are frequently called "suspensoids", those of liquid particles, "emulsoids". The terms, "sol", "suspensoid", and "emulsoid", with their compounds, are properly applied only to systems within the assigned colloidal range of particle size.

Colloidal solutions are referred to as reversible and irreversible, according to whether they will pass from sol to gel and back to sol, or whether, having passed into the gel form, they cannot be reconverted to the sol. The process of passing from gel to sol is called "peptinization". When granular matter also is present, the terms, "flocculation" and "deflocculation", are preferable.

Some colloidal substances (sols) set spontaneously on standing, some by boiling, a large number of the inorganic colloidal substances by freezing, the majority of inorganic colloidal substances on adding to their solutions minute quantities of electrolytes. If re-soluble, sols do not "set" but merely coagulate without setting. When set, sols form amorphous precipitates which are exactly alike.

According to Whitney:

"Whenever any substance which is by nature insoluble in a liquid is produced in a fine state of division in that liquid, it will remain in colloidal state (sol) until coagulated or precipitated by external means".

The size of particle is regarded as due to the "degree of dispersion" of the particulate substance. A decreased size of particle is spoken of as a greater "dispersion", or the substance as more highly "dispersed". By extension, all suspensions and colloids are "disperse" (or "dispersed") systems, or dispersoids; the particles compose the "disperse" phase and the medium is the "dispersion medium". A true solution possesses a molecular or ionic degree of dispersion and is a "mol" or "ion-dispersoid". These terms include all colloidal systems, regardless of the solid, liquid, or gaseous state of the particle or medium.

According to Searle, the most important colloidal substances which are known definitely to exist in clays are: Colloidal silica which may exist in the form of a silica hydrogel, with or without occluded silica hydrosol, the latter being confined to any liquid portions of the clay paste, but distributed

more or less uniformly through the clay slip; and colloidal alumina, of which a small and variable proportion occurs in many clays, especially those known as laterites.

Colloidal ferric hydroxide has been isolated in very small quantities from some ferruginous clays, but clearly cannot be an important cause of plasticity in clays which are almost free from iron compounds. The proportion of water present in colloidal ferric hydroxide is very variable; it parts with water on drying in a similar manner to silica, although it is much more irregular. The variable proportion of water probably explains the variable color to different clays containing iron compounds.

Various colloidal silicates have been found in small quantities in some clays, although absent in many highly plastic clays. The only exception to this is a possible "silicate of alumina" or, more correctly, "alumino-silica acid" (or series of such acids), which appears to be an essential constituent of clays and may be the origin of the colloidal substance to which they are supposed to owe their value.

Colloidal organic matter, chiefly humus, may play an important part in giving to clays their characteristic properties, but as some well-known highly plastic clays are almost devoid of carbonaceous matter, the latter cannot be the chief cause of their plasticity.

From the foregoing, Searle assumes:

"That the characteristic properties of clays are not due to colloidal silica, alumina, ferric hydroxide or organic matter or to colloidal silicates of the alkalies or alkaline earth metals, although when any or all of these are present they may slightly increase the plasticity, or otherwise modify the properties of the clay."

From Ashley's study of the evidence in Clarke's data of geo-chemistry, it appears that the gelatinous silica is most likely to occur in the products of recent rock decay and least likely in old soils.

Suspensions

J. M. Van Bemmelen went into the question of the setting of a clay suspension. As soon as the loosely bound salts are washed out of a clay, it becomes difficult to cause it to settle, and it cannot be filtered, but runs through the filter paper. On adding a small quantity of acid or salt or an alkali, the milk-white liquid coagulates and settles in a short time. It also can now be filtered. Washing again with water, another point is reached when the particles become infinitely fine and pass through the filter.

Adolph Mayer has determined the limiting amounts of electrolytes which will permit a fine clay (free from soluble salts) still to be kept in suspension in water (100 grammes of clay, 500 cu. cm. of water). The limits are: Ammonia, 2.5%; sulphuric, hydrochloric, and nitric acids and the alkali salts of these acids, 0.025 per cent. The practice of the U. S. Bureau of Soils is to add 10 drops of strong ammonia to a 5-gramme sample of clay in 75 cu. cm. of distilled water preliminary to mechanical analyses. With alkaline soils, ammonia hinders the deflocculation and should be omitted.

Disregarding the present conception of colloids as applied to the mining industry, Free considers that he is dealing with a suspension of fine particles in a liquid medium.

In criticizing the concept of gelatinous envelopes about the mineral grains, Free does not exclude the possibility of surface alteration of these grains, such surface alterations being merely part of the phenomena accompanying suspensions, and not to be considered apart from the grain the surface of which they affect, which is very different from an envelopment of the grains by discrete films of alien material. Yet it is not improbable that surface gelatinous films of alien material do exist in certain natural clays and soils.

Suspensions have been thoroughly studied by geologists, soil physicists, and the specialists in colloids. The most weighty result of this study is the possible existence of suspensions of smaller and smaller particles. It is possible to prepare suspensions of clay or other minerals the particles of which are so fine that they remain permanently suspended, although still distinguished by microscopic examinations. It is a short step from this to the typical colloidal solution that appears free of particles before the microscope, and the investigations of colloidal solutions made possible by the ultra-microscope have established the conclusion that the typical colloidal solution, as, for instance, the well-known solution of colloidal gold, is simply a suspension, the particles of which are extraordinarily small.

Relation of Suspensions and Colloids

The important concept here is that of the perfect continuity of the suspension series. There is no natural break or division of any kind between a suspension of coarse gold fragments in water and a colloidal solution of gold particles so fine as to remain permanently suspended and be microscopically invisible. Indeed, if one regards ordinary solutions as composed of single molecules or ions moving through the mass of the solvent, then true solutions appear simply as the limiting case of the suspension series.

The objection to this conception of the unity of the suspension series from visible suspension to the true solution is that the properties of the systems differ markedly in different parts of the series. This is quite true, but close examination of the series shows that all differences are of degree only. For instance, in a coarse sand suspension, the most evident controlling factor is gravity. Nothing but the continuous expenditure of energy (as, for instance, by shaking) will keep the sand suspended. As one considers suspensions of finer particles, gravity grows less and less important, while simultaneously the surface forces between the particles and the aqueous medium grow more and more important, until presently gravity yields control to the other forces and the particles remain in permanent suspension without external assistance. The changes are gradual and always result from continuous increases or decreases in the intensity of affecting factors.

In summary of what precedes, the conception of colloids is regarded as suspensions of very fine particles. No sharp distinction has been made between suspensions and colloidal solutions, but rather in the unity of the series, and in properties other than the substances. Certain colloidal properties, such as slow-

ness of settling and imperviousness of the settled mass, characterize suspensions of finer grain. These may be called colloids. The distinction is relative, as the suspensions are more colloidal than those usually encountered. Typical colloidal properties are best developed within a limiting range of particle size. The size of the particles of the purer clays is comparable with that of colloidal particles, but most clays contain so large a proportion of larger particles that it is almost impossible to isolate those which are colloidal, in an entirely satisfactory manner. There is general agreement on a set of arbitrary size limits in the following classification of solid particles:

Suspensions	Particles over 0.1 micron*	in mean	diameter
Colloidal solutions..	" between 0.1 and 0.001	"	"
True solutions.....	" under 0.001 micron	"	"

Colloidal properties, however, do not necessarily cease to be exhibited by suspensions, the particles of which are outside these limits.

Colloidal Properties

It is manifest that if a colloid is composed of very fine particles of one substance, suspended in another, the total surface of contact between the two substances will be very great. This mutual surface is called the internal surface. It has been found that a number of peculiar properties, of which surface tension is the best known example, characterize all surfaces when two substances come into contact, and the great extent of such surface in supensions and colloids give these surface properties and forces an unusual importance in controlling the salient properties of the entire system. For instance, the phenomena of the absorption or the concentration of dissolved substances at surfaces are exhibited in a high degree by suspensions and colloids.

The large internal surface of colloids means that the surface is relatively large with respect to the masses involved. The criterion is a large ratio of internal surface to mass. The larger the ratio the more colloidal the substance.

Several other properties than the two herein mentioned may be reviewed. Most important are the similarities to, and differences from, the true or ordinary solutions, the particles of which are supposed to be of molecular or ionic dimensions. The typical colloidal solution resembles a true solution in being permanent so long as the conditions remain unchanged; that is, the particles remain in suspension and the colloidal solution retains an unchanged chemical composition.

The colloids differ in (1) failure to show a true and constant solubility; (2) an optical heterogeneity shown by translucence or turbidity; (3) the causing of no change, or a very small change, in the freezing point and boiling point of the solvent; (4) the production of no osmotic pressure; (5) slow diffusion and failure to dialyze or pass through a parchment membrane. The causes of all these differences will be evident on consideration of the differences in particle size which distinguishes the colloids from the true solutions.

Another property is the tendency of the colloidal particles to wander in the electrical field and accumulate at one or the other of the poles. This is dis-

* A micron is one-thousandth of a millimeter.

tinguished from ordinary electrolysis by the fact that the passage of current is not essential. The matter is one of electrostatics and occurs in non-conducting media.

In what precedes, it has been assumed that all colloids consist of solid particles suspended in a liquid medium, but this concept is incomplete. For instance, in the ordinary oil and vinegar salad dressing both particle and medium are liquid, yet the properties of the mixture are typically colloidal. As a matter of fact, it is possible to prepare suspensions and colloidal solutions, the particles of which are either solid, liquid, or gaseous and which are suspended either in solid, liquid, or gaseous media. The medium, or the particle, or both, may be homogeneous or complex.

Whatever is the most probable theory of the constitution of clays, Searle considers that it is certain that some clays are not wholly colloidal in character; they rather resemble a mass of mineral particles, each covered with a film of colloidal matter. If the latter could be wholly separated, it would not possess all the properties of a "clay", in this respect the application of the term "clay" to mixtures of sand and colloidal matter is justified. The laterite clays which are widely distributed in the tropics, are characterized by a large proportion of alumina and silica soluble in hydrochloric acid. The ratio of these two oxides is variable, and seldom reaches 1: 2, which is a conspicuous feature of certain types of the purer clays. This great variation makes it more probable that the laterite clays are merely mixtures of colloidal silica and alumina; their other properties resemble those of such a mixture rather than those of typical clays, and the conclusions based on the results of elutriation may require to be received with caution.

The proportion of colloidal matter which can be definitely separated from clays is extremely small, being less than 3% in the most highly plastic specimens. This small proportion is at first difficult to believe as accountable for the great differences in the behavior of lean and highly plastic clays, and this has been urged as an argument against the plasticity of clays being due to the colloidal material present. On the other hand, there is a close similarity between the behavior of many clays and that of freshly made mortar when the total proportion of colloidal matter present is extremely small. A careful comparison of the structure and properties of such a mortar with those of a plastic clay gives a clear idea of the nature.

The properties of clays which are most closely allied to those of colloids or mixtures of colloids and inert materials differ according as the clays are, respectively, in the "dry", "pasty", or "slip" state. * * * The amount of clay which can be suspended in a given volume of water depends on the physical condition of the clay and the presence or absence of very small amounts of alkali, acids, or salts in the water.

The following properties of clay can be most satisfactorily explained by assuming the presence of colloidal substance:

Water is absorbed by any clay in fairly definite proportions which appear to have some relation to its plasticity, the lean clays absorbing much less water than the most plastic ones.

When clay is completely dried without being excessively heated, it is highly hygroscopic and absorbs water readily—sometimes up to 15% of its weight—without becoming appreciably moist. * * *

The hygroscopic nature of clay distinguishes it from silt and sand. When a piece of air-dried clay is placed in water, the latter enters into the pores, drives out the air, and lifts up the smallest particles of clay, disturbing the structure of the material so that a partial or complete break-down or slaking occurs. The disruptive action of the water on the solid particles forming the clay mass may be attributed to a molecular attraction between the water and the clay whereby the water wets the surface of the latter and the resulting interposed film of water reduces the cohesion of the clay grains so that they separate easily. The quantity of water absorbed varies greatly with different clays; in some cases, it is equal to 80% of the weight of the clay.

Rohland suggests that this power of imbibing a definite quantity of water is due to the colloids in the clay, and that as soon as the clay has absorbed sufficient water to convert its colloids into the form of a colloidal sol, its ability to absorb water reaches a saturation point and ceases; this is proportional to the colloids present, and probably, roughly, to the plasticity of the clay. It may, however, be proportional to the capillary spaces between the clay particles. * * *

If water is added in increasing quantities to a moderately plastic clay that is in a dry state, the clay can at first be moulded with difficulty, then more easily, and, later, it may be moulded with the greatest facility. If the proportion of water is still further increased, the clay becomes sticky, then fluid, and it is eventually impossible to form it into any definite shape.

If the same experiment is repeated with a more plastic clay, using the same proportions of clay and water as before, it will be observed that it will adhere to the fingers and will allow of no further shaping unless its plasticity is diminished by adding non-plastic material or altering the proportions of clay and water.

An excessively lean clay, on the contrary, only acquires the desired plasticity when it has a soft consistency which does not allow it to remain in any given form, and, therefore, it must be rendered more plastic if it is desired that it should be shaped by hand. If the clay is subjected to strong pressure, less water must be added to the body in order to give it the required plasticity, and it will be expedient to make it of a stiffer consistency. Pressure, in this case, plays the same part as water in the plastic qualities of clays; the one can be replaced by the other, so that if the amount of pressure is increased the proportion of water should be diminished and *vice versa.*

If a sufficient quantity of water is added to clay to form a "slip", the latter will have certain characteristics, according to the proportion of water and clay to the nature of the clay and the purity of the water. If the proportion of water is large and the particles of clay difficult to separate, they may fall to the bottom very soon after the mixing ceases, leaving only the smallest particles suspended in the water for many hours. With high-grade clays, such slips have marked colloidal properties.

Clays usually exist in large masses which are not readily affected by water, but smaller pieces may be broken down or "slaked" in a manner which is similar to the deflocculation of colloidal gels. Clays are remarkably sensitive to the action of electrolytes, a small quantity of a solution of soda being capable of converting a clay paste into a viscous fluid which, on the addition of just sufficient acid to neutralize the alkali, will again become solid. This behavior bears a close resemblance to the action of electrolytes on the coagulation and deflocculation of colloids.

The quantity of water absorbed from the atmosphere by the various constituents of clay is remarkable.

Patten and Gallagher report that the quantity of water absorbed from the atmosphere for quartz is 25° cent., vapor pressure 23.50 (water) is 0.61 per cent. Day and Allen report that the water of constitution (about 0.6% for feldspar) is in most cases really hygroscopic, and is greater in quantity the finer the samples are ground.

From these and other authorities it will be considered that the large moisture content of air-dried clays is not wholly due to the granular kaolin feldspar and quartz, but to the organic matter and to the mineral colloidal constitutents of the clay.

Schloesing noted the great bulk assumed by the clay gel in water. Experiments by Patten and Gallagher with Susquehanna clay and various salt solutions confirm the increase of bulk.

Weber has shown that water associated with a gel is dissolved in the gel. Van Bemmelen states that water is homogeneously distributed throughout the substance of the gel, not concentrated on the surfaces like hygroscopic water on glass.

The viscosity of clay suspensions or slips, before and after the addition of various substances, can best be understood by answering that it varies according to the condition and proportion of the colloidal substance present. Mellor, Green, and Baugh have analyzed the substances likely to be present in, or added to, clays into five groups, according to their action on the viscosity of the clay:

(1) Substances which first make the slip more fluid, while further additions stiffen the slip: Sodium and potassium carbonates, etc.
(2) Small amounts thicken the slip; larger amounts make the slip more fluid: Dilute ammonia, copper sulphate, etc.
(3) Substances which make the slip thinner: Magnesium, sodium sulphates, etc.
(4) Substances which only stiffen the slip: Grape sugar, humic acid, ammonium chloride, calcium chloride, etc.
(5) Substances which have no appreciable effect on the slip: Alcohol.

The adsorptive power of clays is similar to that of colloids, or rather to that of a mass of inert material, the particles of which are covered with a film of colloidal matter which also fills some of the interstices. Thus, clays adsorb soluble dyestuffs, oil, salts, tannin, humus, grease, etc. * * *

Many clays retain salts so tenaciously that it is impossible to wash them clean with plain water, but they can be removed by washing with a solution of a salt which is more readily adsorbed by the clay. * * *

The adsorptive power of clay is invaluable in some industries, and it is on account of this power that, if clay is mixed with neutral or slightly acid muddy solutions or emulsions, when the clay settles it will be found to have a clear liquid.

The adsorption of a clay is usually determined by noting the loss of color of a dye solution, such as malachite green, and comparing it with another similar solution to which a standard clay has been added.

If Olschewsky's suggestion that the particles of clay are porous, is correct, the phenomena ascribed to adsorption may really be due to adsorption within the capillaries or pores.

Ashley's Methods of Testing by Malachite-Green Adsorption.—Into a 500-cu. cm. bottle with ground-glass stopper greased with vaseline, 20 grammes of clay and the dye were placed, then 400 cu. cm. of water was added. The closed bottle was then fastened in the frame of a small ball-mill (60 rev. per min.), so that at every revolution it was suspended. This gave a vigorous and complete agitation, which lasted for an hour. Although the clay appeared to settle clear in half an hour, the results were too large and erratic unless the settling continued over night. On the following day, a convenient quantity of the clear liquid was taken out by a pipette and put into one of a pair of "carbon" comparison tubes such as are used in steel analysis, and compared by dilution with a standard solution of 3 grammes per liter, using a camera while matching.

It will be noted that increased fineness of grain is considered as cutting down the plasticity. It has been repeatedly observed that increased fineness of grain of the granular material in a clay or body is a source of weakness and trouble; that, having greater surface, more colloid matter is required to cement the fine granular matter together and so shrinkage and liability to crack are increased.

The capillary phenomena shown by many clays and soils may also be explained on the hypothesis that clays are colloidal in character.

The porosity of clays varies with the quantity of water present, some stiff plastic pastes being quite impervious, although the same materials are porous when dry. This porosity appears to be associated with the capillary structure of many clays and while it is a property possessed by non-colloidal substances, it is a characteristic property of some colloids.

The permeability of clays is dependent on the quantity of non-plastic material it contains, and increases when sand is added. Clay which has been suspended in water and allowed to settle is usually quite permeable as are many natural clay deposits. It is only when the material has been "worked" that it becomes impermeable.

Plasticity may be defined as that property of a material which enables it to change its form without rupture, the new shape being retained when the deformatory force is removed. It is a characteristic of many substances besides clay, although clays possess it to the most marked degree. Ashley has pointed out that the conception of plasticity may vary with the practical use or purpose to which the clay is put. For instance, a jigger-man and a presser in the same clay shop will not agree as to the quantity of moisture

required, and a brick-maker terms a clay plastic when it works well in his machine, but a potter usually places more emphasis on the binding power of the clay, although he terms this its plasticity.

Plasticity varies with different samples and on different occasions, although no raw moist clays are entirely devoid of plasticity. Clays which are quite dry, are not plastic, but become so when mixed with a suitable proportion of water so as to form a paste. Hence, the amount of plasticity developed is dependent on the proportion of water present.

Liquids other than water may be added to the clay to produce plasticity, but they must usually contain water, and even then, they sometimes produce quite different characteristics. Thus, glycerine may be used. Fatty liquids, such as oils, seem to make a more plastic body than with water, especially if the clay has been dried so as to take away from it the hygroscopic water, but alcohol, ether, and turpentine produce bodies with little or no plasticity.

Plasticity also depends on the nature of the fluid and that of the solid. Thus, although both water and oil wet quartz sand, water under suitable conditions will easily displace oil films from a mixture of sand and oil. On the other hand, both oil and water wet zinc oxide, but, in this case, the oil will readily displace the water films, forming paint or putty. The resulting mass, in this case, may be said to be oleated, in very much the same manner as clay is said to be hydrated.

The possible plasticity of clay or other substances cannot be developed by commercial methods of grinding unless the material is in a state which may be regarded as dormant plasticity. This has been regarded as an objection to the view that plasticity is due to the colloidal properties of clay, but the objection may be met by the difficulty of reducing some clays to as fine a state as is required to produce a requisite amount of colloidal matter.

Plasticity also varies with the presence of certain other substances, thus, the following soluble substances reduce the plasticity: Ammonia, caustic soda, caustic potash, lime, sodium carbonate, borax, and water-glass. They appear to do this by coagulating the colloidal portion of the clay, but their action may be prevented by the addition of a sufficient quantity of weak acid, to neutralize the alkali in the clay.

The addition of gum, glue and starch confers a pseudo-plasticity on clay which is, however, quite different from true plasticity, and makes the clay sticky rather than plastic.

Ashley has stated that many plastic bodies consist of a more or less granular material, coated and held by a viscous substance and hardening on exposure to the air or on cooling; for instance, putty, cake frosting, plaster of Paris, wiping solder, mortars, waxes and clays, mixtures of granular, non-plastic materials with moist organic and inorganic gels.

The term, "non-plastic", for granular materials requires qualification, since plastic bodies would lose plasticity if the granular constituent were removed and would become sticky. Plasticity depends on a proper ratio of granular material and viscous suspension medium.

Rohland considers that the plasticity of clays depends on the amount of soluble salts present in the water content rather than on the constituents of

the clay. As clay is plastic, however, when wetted with oil, alcohol, glycerine, etc., the soluble salts cannot play the principal part.

Quoting further from Searle, plasticity has been attributed to the shape or size of the clay particles. Thus, Aron considered that plasticity was due to the particles being spherical, but Zschokke, Biedermann, and Herzfeld dispute this, and attribute it to the presence of flat and laminated crystals, a view early put forward by Johnson and Blake, and held later by Bourry, who stated that plasticity becomes greater in proportion as the grains diminish, and that all minerals if reduced to a sufficiently impalpable powder, will, on the addition of a liquid, produce bodies having a certain amount of plasticity.

According to Chatelier, the lamellar structure and the well-known capillary attraction are a sufficient cause of plasticity. He has shown that all plastic masses contain a large proportion of air by comparing their density with that of clay and water, and that in each plastic mass there are innumerable capillaries of not more than $\frac{1}{3000}$ in. in diameter. He concludes that the tension of the menisci between the water surface and the air surface in the capillaries explains the toughness of the plastic mass, as the capillary force prevents the mass from breaking up under pressure, but allows the minute particles to slip over each other, and yet adhere so strongly that the mass retains the new form when the pressure is removed. In other words, clay is plastic when sufficient water is added to induce the cohesion to a point where it can readily be overcome by the pressure of one's hands, that is, 1 to 3 lb. per sq. in., so that it is a balancing of forces producing a peculiar combination of fluidity and rigidity in the mass of wet clay; under a light pressure it acts as a rigid body, under a heavier pressure it acts as an imperfect fluid. The rigidity is attributed to friction between the clay grains, so that a mass of clay retains its form until acted on by a force sufficient to overcome this friction and produce distortion. The fluidity of the wet clay is due to the freedom of the individual particles to move over each other, after cohesion has been partly neutralized by the addition of water.

The theory that plasticity, instead of being a special property, is simply the molecular attraction, and that all bodies which are made up of laminated particles must become plastic when they are reduced to sufficiently impalpable powder, has been confirmed by Vogt as regards mica, which is highly laminated, being made up of thin layers and when reduced to an impalpable powder becomes distinctly plastic if water is added. The insistence laid by Bourry on the laminated structure of the particles has been frequently overlooked, and the suggestion that, because burned clay may be ground equally fine and yet never become plastic, his experiments are not conclusive, is irrelevant.

Seger and, independently, Schumacher consider plasticity to be due to molecular differences in the clay particles, and Bischof agrees with the latter in considering that clay has undergone great changes in density during deposition, and a kind of "felting" of the particles has resulted so that they adhere much more closely to each other than the quartz and other particles in which this felting process has not taken place.

Wolff has calculated the attraction of the particles of various substances to each other on the assumption that they are spherical. He finds that the

mutual attraction of the clay particles is very high and that the ratio between their mutual attraction for each other and for water is much higher than for any other substances examined. He stated in confirmation of this theory that other substances can be made plastic, if they can be made sufficiently small, as by precipitation. He also pointed out that the combined water in a clay particle increases the ratio considerably and is accompanied by an increase in plasticity not only in the clay, but in alumina and iron oxides. Zschokke confirmed this theory, and has shown that clay particles have a thicker film of water around them than particles of non-plastic materials such as sand.

It is difficult to attribute the plasticity solely to the plate-like or lamellar structure of the particles or to purely mechanical or chemical characteristics in the atoms and molecules of the clay and water, though these are undoubtedly important. Nor has the effort of Le Chatelier to find the source of plasticity in the presence of small amounts of impurities proved really helpful. The smallness and shape of the particles appear to be important, as clay ground in a pan-mill is more plastic than when a ball-mill is used, as the former flattens out the material, but this does not really affect the cause of plasticity. Grinding is not a cause of plasticity, though Johnson and Blake claim to have made a non-plastic china clay plastic by fine grinding.

It has been suggested by Olschewsky, who based his experiments on those of Daubée, that the water used has a chemical action, and that plasticity is due to the formation of a system of capillaries in the clay, a felt-like or spongy material being formed, and, in this way, the clay particles are able to come into closer contact, owing to the production of a kind of gelatinous or colloidal film, but the presence of an alkali appears to be essential for this alteration to take place. * * * The finer a substance is ground the more complete is its re-action with water, because a small particle has a greater surface in proportion to the water than a coarse one. If the particles are sufficiently fine, water may, indeed, act in a similar manner to caustic alkali; thus, very finely divided silica becomes colloidal when brought into contact with boiling water, just as coarser particles do when brought into contact with a boiling solution of caustic potash.

Koerner found that other substances (as alumina) become sufficiently finely divided in water, but their power of cohesion is lost on drying, and suggested that the plasticity may be brought about in a similar manner. This would explain why it is impossible to powder highly plastic clays from kaolin.

According to Searle, whenever plastic clay is subjected to pressure it tends to obey the laws of fluids, transmitting its pressure to all parts of its mass and flowing through an orifice through which it can escape, although it is far from being a perfect fluid. From this arises the modern conception of clay as a very viscous liquid in which every particle of solid matter is surrounded by a film of liquid, so that the particles are virtually in a state of suspension, and, hence, that a plastic clay is, at any rate in part, in a colloidal condition.

In attempting to explain plasticity as being due to colloidal material, it is assumed that some or all of the pores are filled with a colloidal solution (gel) obtained by the partial hydrolysis of the clay, and that the larger the propor-

tion of pores so filled, the fatter and more plastic will be the clay, provided the proper ratio of granular material to colloidal gel is retained.

Rohland and others have further shown that the addition of trifling amounts of electrolytes often produces great changes in the plasticity of a clay, and suggest that this characteristic of colloids is a strong argument in favor of the connection between the colloidal material in clay and plasticity.

Plasticity is not, however, entirely due to the presence of colloidal matter in clays, although the effect of colloids in increasing plasticity cannot be denied. Hermann and others maintain that the presence of inorganic colloids in clays has never been conclusively proved. It should be noted that clay may be suspended in water and then precipitated or deflocculated indefinitely without impairing its plasticity. This is not usually the case with true mineral colloids, which generally set irreversibly and do not return to the colloidal condition. Moreover, the whole of any individual clay grain is not softened on the addition of water. Repeated wetting and pugging does not materially alter the size of the grains or change their general outline or appearance. This would not be the case if the clay were softened and reduced to a homogeneous mass, wetted, and subsequently broken up with the formation of new grains when it was dried and ground. Whether wet or dry, under the microscope, the grains retain the appearance of a sharply defined body.

Van Bemmelen has pointed out the rapidity with which colloids lose their power of absorbing water. This suggests that clays of great geological age cannot contain active colloids produced when the clay was formed, although they may contain colloidal substances derived from adventitious materials, organic or otherwise, at a comparatively recent period. The fact that many highly plastic clays appear to be free from such extraneous colloids only increases the difficulty regarding the latter as the cause of plasticity. Other objections of equal or greater weight may be urged against any single theory yet published on the causes of plasticity so that much further work requires to be done.

In summarizing the results of the numerous theories and experiments made, Searle has stated that plasticity may be said to be due not to one, but to several, causes, the chief of which are:

(1) The nature of the molecules of "true clay" present.
(2) The extremely small size of the particles, their lamellar shape, large surface (due to porosity), and (possibly) their fissile character. In such small particles, the phenomena of cohesion are quite different from those in larger particles.
(3) The hydrolysing action of water on the particles and the probable production of inorganic colloid matter.
(4) The presence of organic colloid matter due to impurities in the clay, or added purposely, may still further increase the plasticity.
(5) The presence of minute quantities of soluble salts may exercise a pronounced effect on the plasticity. Plasticity appears to be a resultant of several properties (cohesion, adsorption, tensile strength, binding power, etc.)

The measurement of plasticity is a problem which has not yet been satisfactorily solved, probably for the reason that plasticity is the result of the united action of several forces, some of which may not, as yet, have been

recognized as important. Measurements of tensile strength, viscosity, and the quantity of water required to produce a mass of given consistency, Sokoloff's slaking test, and other single characteristics fail to include all the properties involved in the term "plasticity". Zschokke, who has examined the subject very fully, considers that the percentage of extensibility multiplied by the tensile strength of a freshly moulded clay cylinder of standard size (66 mm. high by 30 mm. in diameter) is a coefficient of the plasticity. Grout considers that plasticity is proportional to the product (*a*) the load required to sink a Vicat needle to a definite depth in a mass of clay; and (*b*) the deformation of the clay under stress, which he measures by the increase in area of a clay cylinder produced by a load which first causes cracks to appear. Both Zschokke and Grout really consider plasticity to be measured by the product of the deformability and force-resisting deformation, although they differ in the manner in which they measure their forces. Ashley has adopted the same general idea as to the forces involved, but has assumed that the force-resisting deformation is exerted by the colloids in the clay. He, therefore, regards the plasticity of clay to be measured by the ratio:

$$\frac{\text{Relative Colloids} \times \text{Air Shrinkage of the Clay}}{\text{Jackson-Purdy Surface Factor}}$$

As the ratio of the surface factor to shrinkage is approximately constant, Ashley concludes that the plasticity of the clay is directly proportional to the colloids present; but it appears unlikely that the whole of the plasticity is due to the colloidal matter.

Rohland, also assuming that the colloidal matter in the clay is the chief factor of the plasticity, has suggested that the ratio obtained by dividing the coagulable colloids by the non-coagulable material is a measure of the plasticity. He ascertains it by measuring the quantity of water required to make the clay into the consistency of a good modeling paste, and argues that this is a measure of the colloids because as soon as sufficient water is present to dissolve the coagulable colloids, a saturation point is reached, and no more water can be absorbed without the clay losing its stiffness.

Stormer has stated that plasticity may be judged by the following characteristics:

(1) The proportion of water which must be added to the clay to make a good modeling paste. This is not always reliable.

(2) The "feel" of the paste when rubbed between the finger and thumb.

(3) The behavior of the paste when rolled into a "sausage".

(4) The adhesiveness of the clay.

(5) Twisting a piece of clay into a spiral and noting its behavior.

(6) Noting the length of the threads, produced by expressing the clay from a vertical pug-mill, before they break off by their own weight.

(7) Forming balls of clay and pressing them until the edges crack.

(8) Bending cylinders of clay into a ring.

None of these characteristics taken alone can give a measure of the plasticity of a clay, although several of them are closely related to each other. The most reliable measure of plasticity appears to be that devised by Zschokke,

or by Rosenow, who multiplies Zschokke's figure by the percentage of water added to the dry clay to make it into a workable paste, that is, by Rohland's figure.

Binding or Binding Power of Clay

The binding power of a clay is the property it possesses of uniting with non-plastic material and water to form a uniform plastic paste and is, consequently, closely related to the plasticity. This absorption of non-plastic material with the spread of plasticity throughout the whole mass has been attributed to the power of the saturated colloids (gels) to retain the non-colloidal particles in a state of pseudo-solution. Other colloids are known to possess the property of preventing insoluble matter from settling and this is, in some senses, a parallel case. The binding power of a clay may be determined by measuring the tensile strength of mixtures of clay with varying quantities of sand, but a skilled clay-worker can tell by the "feel" whether such mixtures are strong enough to be useful. Clays with a high binding power are known technically as "fat" clays; "lean" clays are deficient in binding power.

Some writers appear to consider that binding power and plasticity are synonymous. This is by no means the case, as a clay may be very plastic and yet not be able to bind much non-plastic material into a uniform paste. At the same time, there is clearly some relationship between these two properties of clays.

The dehydration of clays is accompanied by changes which are remarkably similar to those which occur in the dehydration of colloidal gels. The most important of these changes is the shrinkage or contraction of the mass, the production of a hard material which, if the dehydration is accomplished by heat, may result in the production of a material comparable to an irreversible gel.

Plastic clays, like colloidal gels, shrink greatly when dehydrated and possess an air-drying shrinkage. By mixing an inert substance, such as sand, with a true colloid, the shrinkage is lessened, and the cohesion of the dried colloid, including its adhesion to inert substances, is the cause of the increased mechanical strength of many such mixtures. This is another characteristic common to colloids and to all plastic clays.

As there is no wholly reliable method of measuring plasticity, it is not possible to state precisely what relationship exists between the plasticity and the shrinkage of clays. Speaking broadly, the most plastic clays shrink more than those which are less plastic, but this is not invariably the case. For instance, the Lias clays usually shrink less than would be expected from their plasticity.

When articles made of plastic clays are dried under suitable conditions, they contract equally in all directions, the contraction in volume being almost three times the linear shrinkage. Excessively plastic clays crack or twist when dried and many moderately plastic clays will do so if dried irregularly or too rapidly.

When water is added to a dry clay, it is first absorbed by the pores, but when these are filled, any further supply of water appears to cause a separation of the particles from each other so that the volume of clay is increased, although not in proportion to the water added. The quantity of water which can be absorbed in this manner differs greatly with different clays. The stage at which the clay contains the maximum quantity of water without loss of shape is also the point of maximum plasticity; it is said to be the "point of saturation of the coagulated colloids (gels) in the clay". If some of this water is removed, the volume of the mass begins to diminish and contraction occurs. This contraction or shrinkage is chiefly, but not entirely, due to the removal of water from the clay by evaporation at the ordinary temperature (air shrinkage).

As all coagulated colloids (gels) which are saturated with water shrink when the water is removed, some investigators consider that the shrinkage of clay may be due in part to this cause. The more general idea (which states facts rather than explains them) is that, as the water is removed, any which remains draws the clay particles together into a smaller and denser mass.

The amount of shrinkage appears to depend partly on the rate at which the clay is dried, for if this operation is performed rapidly, the shrinkage will be less, the clay particles not having time to move over each other so freely as when the drying is slower. When drying a strong porous clay, the water first evaporates from the surface and is replaced by capillary action from the interior, the mass contracting by the same amount as the water diminishes. All the pores remain filled with water until the rate of evaporation exceeds the rate at which the pores will transmit water.

This point occurs when the clay particles move so much less freely on each other that the rate of evaporation exceeds that of the contraction. After the first stage of surface drying, the exterior loses water more rapidly than the interior; in the second stage, the pores are no longer filled with water at their outer ends and begin to form spaces in the clay, these spaces being filled with air and water vapor. Contraction still occurs throughout this second stage until the substance is so far solidified that the individual particles can no longer slip over each other at all. The third stage is then reached in which capillary action and shrinkage cease entirely. Evaporation now takes place entirely within the mass, and spaces are formed exactly corresponding to the water lost. That shrinkage ceases entirely before the clay is deprived of water is shown by Aron and Brogniart to be characteristic of many but not of all clays. Aron supposed that the clay shrinks until the particles are practically in contact with each other, so that any further water which may be driven off does not make any notable difference in the volume of the clay; but supporters of the colloid theory argue that the heat used in drying really causes the colloid particles to shrivel, thus reducing their surface and increasing their density. Aron has further shown that the "pore space" is constant for each kind of clay, and is dependent on the quantity of water of formation added to the clay, although this last statement is only true of the purer clays.

If now, the pastes made with varying quantities of water of formation, are subjected to exactly the same conditions of drying, the rate is not proportional to the water added, but is slower in proportion for those with less water. It takes, approximately, the proportional time in the first two stages of drying, but the more solid the mass, the longer it takes to eliminate the last portions of the water.

In the second stage of drying, all clays lose water more rapidly on the outside than on the inside. The consequence of the greater shrinkage of the outer layer is a frequent cause of cracking.

In general, the greater the proportion of non-plastic material in the clay, the less it will shrink, and the greater will be the porosity. The nature of the non-plastic material will also affect the shrinkage to some extent, and will exercise a considerable influence on the quantity of water absorbed by the clay. Thus, a porous, burned clay will absorb more water than sand. The porosity of a dehydrated clay appears to be due to the capillary structure of the material.

Other properties which clays in the plastic state possess in common with colloids are:

(1) Cohesion is closely allied with extensibility, or the ability of clay to stretch when pulled, which is measured by ascertaining the fullest extent to which a clay test piece of a given size will stretch without breaking.

(2) Torsion, or the extent to which a piece of clay can be twisted, which is measured by clamping one end of a bar of clay as rigidly as possible and rotating the other slowly by means of a screw, counting the number of complete revolutions which can be made before the bar breaks.

(3) Bending moment, or the angle through which a bar of clay can be bent without rupture.

(4) Elasticity, or the extent to which a piece of clay can be stretched and yet return to its original length when the tension is removed.

The tensile strength of a clay is its resistance to being pulled apart. The non-plastic materials influence its strength inversely as the diameter of their grains, so that finely grained clays will usually be the strongest, although an excess of very fine or very coarse grains will cause the clay to break prematurely. In support of the theory that the grains of clay interlock to some extent, Ries found that mixtures of two clays can be made, which have a higher tensile strength than either clay taken separately. * * * It has sometimes been stated that the tensile strength of a clay enables it to carry a large quantity of non-plastic material, but this is rather confusing the effect with the cause. Olschewsky has proved that there is no direct relationship between the binding power of a clay and its tensile strength when dry. It was at one time thought that the tensile strength of clays is proportional to the plasticity, but this is only true, if at all, when the pieces are tested in the moist (plastic) state. If air-dried, the definite relationship ceases.

The tensile strength of dried raw clays depends on the proportions of the grains of different sizes. Equal sized grains cannot be packed into a dense mass. An excessive proportion of the finest clay particles or a large percentage of sand grains (0.5 to 1.0 mm.) weakens the strength of an air-dried clay.

From the foregoing, there appears to be a close parallelism between the more important properties of plastic clays and those of other colloids, but the question still remains as to whether these colloidal properties are due to the nature of an essential constituent of clays (clay substance) or to other colloidal substances which may be present.

It has been suggested in the foregoing that the more important properties of clays may be due to the presence of colloidal matter in them. It has been shown that colloidal matter does exist in clays and that many of the characteristic properties of clays are equally characteristic of colloidal gels, although none of the latter possesses all the properties of a valuable plastic clay. The question, therefore, arises as to whether the so-called colloidal properties of clays are merely coincidental with the composition of clays, or whether plastic clays contain some substance or substances not hitherto identified as a colloidal gel.

There can be no doubt that most plastic clays contain a large proportion of non-plastic and non-clayey material and may be regarded as diluted clays. Some of the most highly plastic clays, on the contrary, consist of such small particles that the non-clayey matter cannot be satisfactorily separated. On the one hand, attempts to separate an ideal "clay substance" by chemical or mechanical methods have resulted in a material which is almost devoid of plasticity, and on the other hand, attempts to show that clays are essentially colloidal have not satisfactorily produced any definite colloidal substance which can be regarded as clay. We are compelled, therefore, to realize that many of the more important properties of clays are due to the colloidal nature of the material, although clays are not wholly colloidal, and that this essential colloid has not been identified. In so far as it does exist, it appears to be (*a*) a colloidal alumino-silicic acid widely distributed through a mass of inert granular material of the same chemical composition, or even of an entirely different one, such as sand, the whole being comparable to a freshly made concrete, but differing from the latter in requiring heat to "set" it. Alternatively (*b*), the colloidal material may be a mixture of colloidal silica and colloidal alumina precipitated simultaneously from the sol state in such a manner as to appear to be a definite chemical compound. This possibly can only be confirmed or disproved by a large amount of experimental work which is not yet completed. The chief difficulty in accepting the alternative hypothesis is that, if it were correct, it should be possible to isolate relatively large quantities of colloidal silica and alumina from such highly plastic and relatively pure clays as the ball clays, but this has not been accomplished. This may be rendered difficult or impossible by the mutually coagulated silica and alumina gels behaving as a compound in which the silica and alumina have so great an affinity for each other that they cannot be separated by means applicable to the isolation of the simpler gels. Finally (*c*), as almost any material may, by suitable treatment, be converted into the colloidal state, the characteristic properties of plastic clays may be independent of the chemical composition of the colloidal matter present in them. If this was the case, any mineral substance which could be converted into colloids by the natural agencies to which clays had been subject, would be possible sources

of clay. This explanation has the great advantage of accounting for the small proportion of colloidal matter present in even the most plastic clays, as if such colloidal matter was the result of age-long grinding of minute rock particles under water, it is only natural to suppose that the product of such action would be grains of the original rock surrounded by a film of colloidal material. If, on the contrary, clays are produced by mixing colloidal matter (formed separately) with non-plastic grains, it is most likely that considerable quantities of such wholly colloidal matter would be found in small pockets or fissures in clay beds. This does not appear to be the case.

If any or all of these three alternatives were correct, they would explain many of the known properties of clays. Both silica and alumina gels readily become irreversible; even when prepared under the most favorable conditions, they are much less "manageable" than many other colloids. Hence, it is only to be expected that if a complex gel, containing both silica and alumina in intimate admixture, or even in a state of combination, would be extremely difficult to isolate in an approximately pure state.

As far as can be ascertained at present, the colloidal material to which clays appear to owe their characteristic properties has been produced by the very prolonged action of water on rocks, chiefly those composed of one or more alumino-silicic acids, the precise nature and origin of which is still uncertain, although represented roughly by the formula, $H_4Al_2Si_2O_9$, in the case of Cornish china clays, Dorset and Devonshire ball clays, and possibly of other less pure clays. This colloidal constituent of clays appears to be a very finely divided, solid, cellular substance (it need not, of course, consist of any one chemical compound; even if it consisted chiefly of one such compound, it would seldom, if ever, be pure), which can absorb water like a sponge, thereby forming a kind of jelly which retains the water by capillary attraction and only permits it to evaporate very slowly at the ordinary atmospheric temperature. Consequently, the proportion of water present in a clay paste of given consistency is a rough measure of the colloidal matter present and when precisely similar clays are compared, it may also be a measure of the plasticity of the paste; the latter property is partly due, however, to the size of the grains coated by the colloidal material and by the thickness and other physical characteristics of the colloidal coating, and the extent to which it penetrates any pores or interstices in the granular material. Various attempts to synthesize "true clay" have been unsuccessful.

At present, it seems to be quite impossible to be certain of the composition of the substance or substances to which clays owe their chief characteristics. The reporter favors the view that age-long grinding has produced a film of colloidal matter on grains of non-plastic material as probably accounting for most clays, but he also believes that no single cause can account for the formation of all kinds of clays, and that other explanations may be equally correct in some cases. The fact that the finer particles of all plastic clays correspond more or less closely to the formula, $H_2Al_2Si_3O_9$, does not necessarily invalidate the theory that clays are simply a product of intensely ground rocks, as there are many clays which do not correspond to the formula just mentioned, and some of these which correspond to it more closely are

only feebly plastic. The similarity in composition of materials regarded as clays may, possibly, be merely a coincidence due to the predominating proportion of alumino-silicious rocks in the material of which the earth's crust consists.

Whatever its nature and origin, it is now fairly well established that many of the properties of clays are closely connected with the colloidal matter present, such matter being in the form of a film of colloidal gel surrounding particles which are of a non-plastic or colloidally inert nature; in some cases, they may be rich both in alumina and silica—as in china clays and ball clays—while in others they may be almost wholly silicious, as in fireclays and many brick clays.

The particular kind and quantity of gelatinous matter present, the size and shape of the grains of non-colloidal material, and the relative proportions of large and small grains are important factors in determining the various physical properties of clays, particularly their binding power, compressive strength, tensile strength, and air shrinkage.

Very recently, Anderson and Fry completed a preliminary study of the solid phases obtained by the evaporation of certain soil extracts. In order to obtain sufficient material, they found it necessary to work up from 500 to 2 000 lb. of soil. The amount of colloidal material obtained from so large a quantity of extract was, of course, considerable, and it possesses such striking properties that some time was devoted to the study of it.

Method of Preparation.—A battery of barrel-type churns was used for stirring up the soil with water; 25 lb. of soil were placed in each churn and 125 lb. of pure distilled water added. The churns were rotated for several hours and then allowed to remain at rest for 24 hours before the supernatant liquid was siphoned off into well-tinned milk cans. The next step was to pass the turbid liquid through a Sharpless centrifuge. While this is a continuous process, it is calculated that each portion of the liquid was subjected to the force of 17 500 gravity for at least 5 min. The liquid issuing from the centrifuge was usually quite opalescent with colloidal material, which was next separated from the dispersing medium by means of batteries of Pasteur-Chamberlain filter tubes (Bogie F). The clear filtrate was concentrated in steam kettles for other researches. The colloidal material collected on the outside of the tubes in a slimy, sticky mass which soon clogged the filters. However, it was easily removed by blowing air into the tubes. The name, "ultra clay", has been given to this material.

The ultra clay was purified in many instances by dialysis. This process proved very slow and was finally given up, and the purification was carried out by stirring the colloid with distilled water and drawing the water off by clean filter tubes. This method was very satisfactory.

The chemical composition of ultra clay varies considerably. The investigators are convinced that it is a mixture of colloids, consisting mainly of the hydrated silicate of aluminum, and containing varying amounts of ferric hydroxide, silicic acid, organic matter, and possibly aluminum hydroxide. There are always present small, but varying, amounts of calcium, magnesium,

potassium, and sodium. Whether chemically combined or physically absorbed has not yet been determined.

When ultra clay is suspended in water, it gives every evidence of being a true colloid. Under the ultra-microscope, it appears as droplets of an amber yellow color and shows the Brownian movement to a very marked degree. When very dilute solutions of electrolytes are allowed to diffuse under the cover glass on the slide, the Brownian movement is at once arrested. When suspensions are concentrated, much flocculation occurs. The addition of any electrolyte, or of alcohol, will, of course, have the same effect. When the thick mass is diluted or the coagulating material is removed by washing, a free suspension of the colloid is again obtained. If the colloid is very thoroughly dried on the water bath, it re-suspends in water very slowly. The dry material is resinous and of an amber yellow color.

Clay soils that have been thoroughly elutriated, as in the mechanical analysis of soils, lose much of their plasticity. The ultra clay, on the other hand, is very plastic when moist, and exceedingly sticky. Certain experiments have been carried out to determine the adhesive properties of ultra clay. The results recorded in Table 1 show that, up to 10%, ultra clay is a much stronger binding agent than Portland cement. However, this is true only when the material is dry. Briquettes cemented together with ultra clay go to pieces very readily when thoroughly moistened.

TABLE 1.—Crushing Strength of Briquettes.

Percentage of cementing material.	Portland cement, in kilos.	Cecil ultra clay, in kilos.	Susquehanna ultra clay, in kilos.	Commercial kaolin, in kilos.
With Standard Grade of Sand as that Used in Cement Testing:				
0.00	0.00	0.00	0.00	0.00
0.50	0.00	3.13	5.42	0.00
1.00	0.00	7.35	6.70	0.00
2.00	0.00	13.48	......	....
5.00	3.23	61.57	54.84	0.00
....	19.16	122.52	96.39	....
With Quartz Flour:				
0.00	17.38	17.38	17.38	17.38
0.50	29.86	33.66	28.08	17.56
1.00	44.37	50.61	52.32	19.40
5.00	72.89	65.54	69.70	17.96
10.00	85.32	128.18	80.68	......
....	112.30	304.30	206.82	......

The briquettes were 25 mm. high and 25 mm. in diameter, made up with 18% of moisture, under 1 800 lb. pressure per square inch and dried at 100° cent.

It seems evident, therefore, that ultra clay is the principal binding material of the soil, giving it plasticity, cohesiveness, or hardness, according to the moisture content. The recognition of these important properties shows the fundamental relation the material bears to certain engineering problems, including sub-grades in road construction.

The possibility of finding a means to control certain of these properties offers a field of research, with the promise of results of economic importance to agriculture and to engineering. It is not a question of minute particles sticking together, but of the actual presence of a powerful binder, the nature of which is destroyed by the application of heat.

Bibliography

Seger. Gesam. Schriften. Ed. by H. Hecht and E. Cramer. *Tonindustrie Zeitung,* 1908.

Asch, W. and D. The Silicates in Chemistry and Commerce. Lond., Constable & Co.

Martin, G. *Chemical News.*

Schloessing. *Compte Rendus,* Vol. LXXIX (1874), pp. 376–380, 473–477.

Rohland, P. Die Tone.

Searle, A. B. An Introduction to British Clays. Lond., Griffin, 1911.

Ashley. *Transactions,* American Ceramic Soc., Vol., XII (1910), p. 768.

Schurecht. *Journal,* American Ceramic Soc. (1919), pp. 443–450.

Kosmann. *Tonindustrie Zeitung* (1895), p. 352.

Zebisch. Sprechsaal (1894), p. 1028.

Mellor, Green and Baugh. *Transactions,* Eng. Ceramic Soc., Vol. VI (1906), pp. 161–170.

Ostwald, W. Colloid Chemistry.

L'Hermite. *Annales Chim. Physique* (3) (1855), pp. 43, 352.

Zschokke. Chem. Technologie der Neuzeit, Bd. 1, p. 775.

MacMichael, R. F. *Brick and Clay Record* (1919), p. 690.

Bourry. Treatise on the Ceramic Industries. Lond., Scott, Greenwood & Son, 1911.

Grout, W. Virginia Geological Survey, Vol. III (1906).

Cushman, A. *Transactions,* American Ceramic Soc., Vol. VI (1907), p. 7.

Bemmelen, J. A. Van. *Zeitschrift anorg. Chemic,* Vol. V, p. 466; Vol. XIII, p. 233; Vol. XVIII, p. 14; etc.

Pukall, W. *Berichte* d. deutsh. d. Chem. Gesellschaft, Vol. 43 (1910), p. 2107.

Ulzer, F. *Zeitschrift anorg. Chemic,* 28, 1, 308 (1915).

Weston, F. E. *Chemical Age,* January 17th, 1920, pp. 58-60; January 31st, p. 115; February 7th, p. 146; February 14th, p. 170; March 6th, p. 247; April 3d, p. 351; also, "Colloidal Clay", *China Clay Trade Review* (1920), p. 337.

Hay, J. Gordon. Colloidal Clay as a Catalyst in Oxidation and Hydrogenation, *Chemical Age,* February 21st, 1920, p. 194.

Ormondy, W. R. The Filtration of Colloids. Society of Chemical Industry Conference, July, 1920.

Arndt, Kurt. A Popular Treatise on the Colloids in the Industrial Arts, tr. by Nahum E. Katz. Easton, Pa., 1914.

Ashley, H. E. Theory of the Settlement of Slime. *Mining and Scientific Press,* Vol. XCVIII (1910), pp. 380–395.

Caetani, Gelasio. Sand, Slime and Colloids in Ore Dressing. *Mining and Scientific Press,* Vol. CVI (1913), pp. 438–442.

Gassuto, L. Der Kolloide Zustand der Materia. Leipzig, 1913. 252 pp.
Freundlich, Herbert. Kapillarchemie. Leipzig, 1909. 565 pp.
Hatschek, Emil. An Introduction to the Physics and Chemistry of Colloids. Lond. and Phila., 1913. 87 pp.
Ostwald, Wolfgang. Grundriss der Kolloidchemie. Dresden, 1909. 509 pp.
Taylor, W. W. The Chemistry of Colloids. Lond., 1915. 328 pp.
Zsigmondy, Richland. Kolloidchemie. Leipzig, 1912. 281 pp.
Rohland, Paul. The Colloidal and Crystalloidal State of Matter.
Zsigmondy. (Spear) Chemistry of Colloids.
Poschel, Victor. Chemistry of Colloids.
British Association for Advancement of Science, Vol. 1-2 (1917–18).
Burton, E. F. The Physical Properties of Colloidal Solutions.
Ostwald and Fischer. Theoretical and Applied Colloid Chemistry.
Moore, Charles J., William H. Fry, and Howard E. Middleton. Methods for Determining the Amount of Colloidal Material in Soils. *Journal of Industrial and Engineering Chemistry,* Vol. 13, No. 6, pp. 527-530.

APPENDIX IV

PROGRESS REPORT OF TESTS ON UNDISTURBED CLAYS

By J. H. Griffith, M. Am. Soc. C. E.

Purpose and Plan of Investigation

General Statement.—There are recorded in the following pages the results of a field investigation to determine the physical properties of soils as they exist in their natural beds. This research was performed by the Engineering Experiment Station of Iowa State College for the Soils Committee of the American Society of Civil Engineers. It was conducted in conformity with a plan already adopted by the Soils Committee in having different laboratories carry out its general plan of research. The work may be considered to supplement the previous investigations already made in harmony with the plan of the Committee. A number of new projects have been initiated in the present investigation.

Outline of Program of Investigation.—The program of research here submitted in abstract was planned by the Director of the Engineering Experiment Station of Iowa State College, Anson Marston, M. Am. Soc. C. E. It was suggested in brief that:

(*a*). The various physical properties of the earths in their undisturbed states in Nature be determined, *viz.,* the tensile, compressile, shearing, transverse, and such other "strengths" as seemed important and as found at particular depths below the surface. It was thought to be desirable in this connection that those areas which were to be exposed to stress in the experimentation should be sufficiently large as to be commensurable with the needs of the practicing engineer in his field and office work.

(*b*). It was furthermore desired that various supplementary tests considered important by the geologist and soils physicist should be determined, namely, the true and apparent specific gravities, specific weights, percentages of capillary and hygroscopic moisture existing at the time of the major tests, mechanical analyses, coefficients of friction, porosities, constants of flow of water through soils, and such other factors as seemed important and will be discussed later.

(*c*). Chemical analyses to determine the typical constitutions of the several classes of soils encountered, were considered essential.

(*d*). A study of the colloidality of clay was suggested and will be taken up in due course.

(*e*). Finally, it was decided to determine the laws of variation of pressure existing in the case of actual earths when they are subjected to various types of loading and under different seasonal conditions.

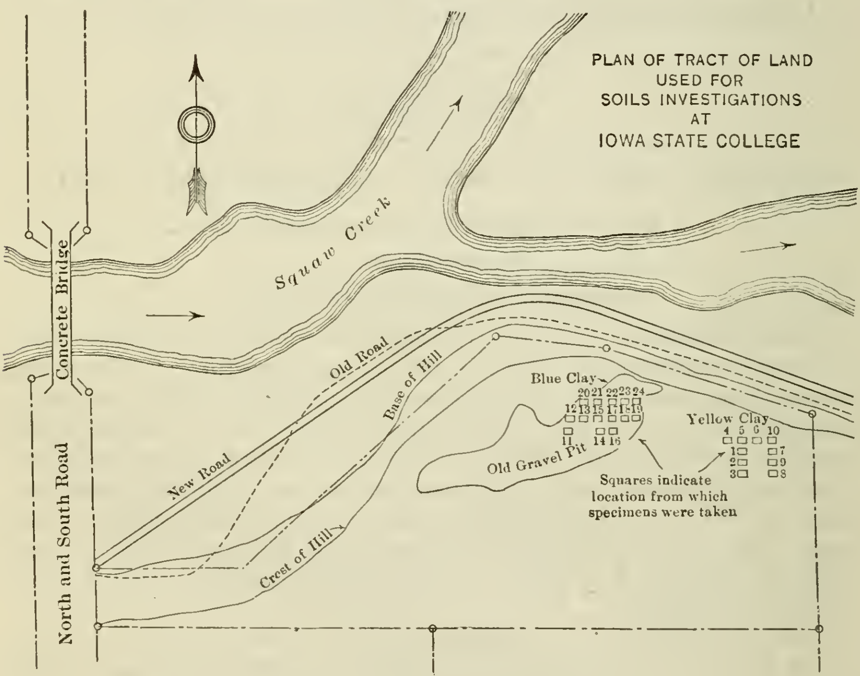


FIG. 4.

This investigation has been conducted on a 3-acre tract of land which has been set aside by the Iowa State College Administration for the purposes at hand, together with such other investigations of this character as have been previously initiated or will be conducted along related lines. A sketch of the tract in plan and its environs is given in Fig. 4. The location from which the specimens for tests were taken has been indicated.

Thus far, it has seemed advisable to consider the extension of this work through the two summer periods of 1921 and 1922, and the work attempted

so far has been arranged on that basis. The work completed to date has been recorded and discussed to some extent in this report which has been largely confined to the measurements and a study of the behaviors of the particular earths and top soils thus far encountered. The field operations necessary and preliminary to the determination and study of stress distributions had not sufficiently progressed to the present time as to afford data for this report.

Personnel and Acknowledgments.—The execution of the plan of research was entrusted to the writer. He was assisted by the following associates: Mr. L. W. Mahone assisted in the field investigations, took charge of the mechanical analyses and moisture determinations, made a number of the specific gravity determinations, and carried out numerous computations. He was assisted partly in his work by Mr. G. T. Williams. C. E. Hanson, Assistant Professor of Mechanical Engineering, Iowa State College, served as photographer, and made a number of field tests.

The investigational force acknowledges the cordial co-operation of Dr. O. R. Sweeney, Head of the Department of Chemical Engineering of Iowa State College, who has kindly consented to initiate the investigation on the colloidality of clays, which will be carried out in detail by the operating force. Paul E. Cox, Professor of Ceramics Engineering, was frequently consulted as to the properties of clay. The services of E. H. Richardson, College Photographer, are acknowledged in photographic work. The Department of Soils of the College through Mr. B. J. Firkins gave the investigators access to its methods in conducting physical tests of soils, which were valuable in arranging methods and perfecting details of the investigation.

Discussion of Tensile Tests

1.—Methods of Procedure

(a).—Preparation of Test Specimens.—The test specimens in accordance with the program, were to be prisms cut out of the solid earth without injury to its structure, these prisms to be enclosed by a suitable box or draw-head, being finally encased within the draw-head by a shell of concrete. Quick-setting plaster of Paris and sand was substituted as a casing for the sake of expedition in view of storms, flooding, summer heat, and other exigencies with which it was found necessary to contend later.

It was found advantageous to proceed as follows in preparing test specimens: The earth was denuded until the proper stratum of clay was exposed. The depth of the stratum was 5 or 6 ft. below the surface, in the case of both the yellow and blue clay thus far studied. The clay was cut into grooves or valleys about 3 to 4 ft. wide by 2½ ft. deep, leaving several ridges exposed above the depressions, rectangular in section, and of approximately the same dimensions as the preceding. The ridges were divided transversely by narrow grooves, using sharpened spades for the purpose, thus "blocking out" prisms roughly approximating the finished prisms. The finished specimens were finally obtained by "chiseling off" the excess material—usually 6 to 12 in. thick—to give the appropriate working dimensions. The finished

test pieces were square in section and were really inverted frustrums of square pyramids, the lateral faces being beveled to an angle of approximately 1:12 slope. The net section at the base of the enclosing box was intended to be 16.97 in. square to give a net area of 288 sq. in., or 2 sq. ft. The box was constructed of 2-in. Oregon fir, was well braced, and in vertical height was 18 in.

(*b*). *Method of Test.*—A specimen ready for test after the plaster casing has well set is shown in Fig. 5, which will need little description. Care was exercised in centering the overhead frame to avoid eccentricity of loading. Power was applied through the 1-ton chain hoist shown in the photograph. Maximum loads at failure were observed with a Kohlbusch dynamometer of 6 000 lb. capacity, which could be read to 5 lb., being provided with actual and maximum load index pointers. The weight of the draw-head and contained earth as given by the former were subtracted from the maximum loads observed to give the maxium force at rupture. The dynamometer was calibrated on an Olsen testing machine and found to read from 50 to 100 lb. under the real weight. All loadings recorded were corrected in accordance with the calibration.

2.—Results of Tensile Tests

The results of tensile tests on the yellow and blue clays are shown in Table 2 and Fig. 6 which gives a graphical representation, the abscissas indicating the number of the specimens and the ordinates the stresses, in pounds per square foot, at failure. The heights of the bands indicate the relative strengths of the yellow and blue clays and the variation from the mean values as shown by the horizontal lines. These results fall fairly within the range of 160 to 800 lb. per sq. ft., as given by W. Airy.*

The maximum load index advanced rather rapidly to its upper limit during the operation of the hoist. The other index followed and then lagged and retreated from 20 to 30 lb., as different increments of loading were applied nearly continuously; which shows a slight tendency to stretching of the clay during its tension. It was the intention to make measurements of the stretch, as in the case of shear and compressile tests which are given later, but on account of the difficulties encountered in plowing the valleys, this was deferred until later. The surfaces of the fracture at the level of the draw-head were characteristic throughout, the surfaces fracturing convex upward (but sometimes downward) from 0 to 5 in. in all cases. The reason for this convex surface of fracture is doubtless the same as that existing for the nearly ellipsoidal variation of velocity in the case of laminar flow of water in a pipe, or that existing for the "cone and cup" fracture in steel bars after tests. In the first case, the water is restrained at the outer cylindrical wall by friction. In the second case, the outer rolled "shell" of steel is stronger than the interior material. In the case of the tensile tests of clay, the walls of the box container and the additional hard shell of plaster of Paris doubtless restrain displacement of the particles in much the same manner. In one instance,

* Discussion on paper by the late *Sir* Benjamin Baker, Hon. M. Am. Soc. C. E., "The Actual Lateral Pressure of Earthwork," *Minutes of Proceedings*, Inst. C. E., Vol. LXV. (1880-81), p. 188.

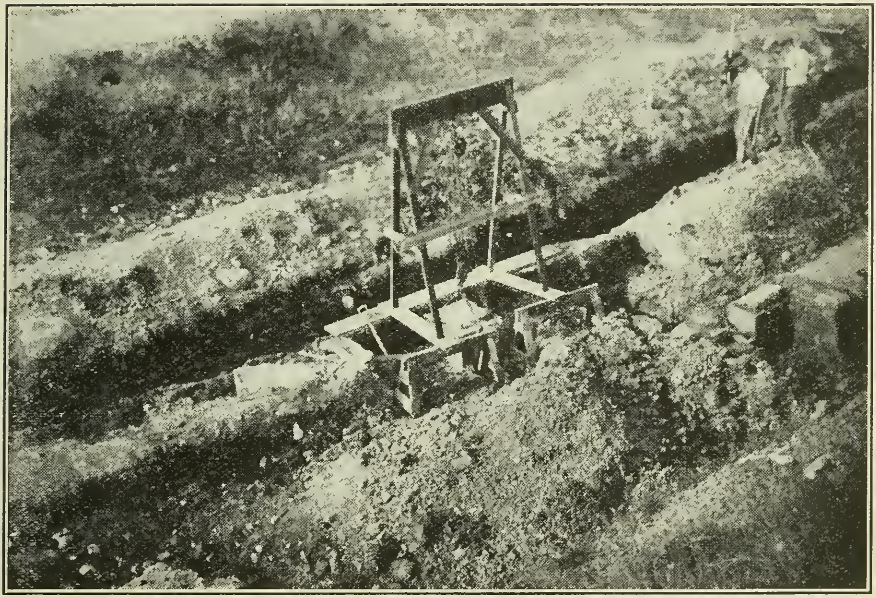


FIG. 5.—CLAY SPECIMENS READY FOR TENSILE TESTS.

time, rates of displacements or velocities are considered; in the other, displacements alone.

TABLE 2.—TENSILE TESTS OF CLAY.
(Apparatus Shown in Fig. 5.)

Date of test, 1921.	Serial number of specimen.	Dimensions at fracture, in inches.	Area, in square feet.	Tensile load, in pounds, at rupture.	Maximum tensile stress in pounds per square foot.	Remarks.
July 29....	T 1	16.87 by 17.06	2.00	425	212	Fracture concave down.
August 3	T 2	17.0 by 17.0	2.01	190	95	Rained cont. Aug. 1, clay stiff and firm, fracture plane.
" 3	T 3	17.0 by 17.0	2.01	310	154	
" 4	T 4	17.0 by 17.0	2.00	510	254	Nearly plane fracture.
" 4	T 5	17.5 by 17.25	2.10	375	179	Fracture slight concave down.
" 5	T 6	17.5 by 17.5	2.12	470	221	Fracture nearly plane.
" 8	T 7	17.5 by 18.0	2.19	480	219	Fracture convex up 2 in.
" 8	T 8	17.0 by 16.5	1.94	440	226	Fracture nearly plane.
" 9	T 9	17.5 by 17.5	2.12	545	256	Fracture nearly plane.
" 9	T10	17.0 by 17.0	2.01	600	299	Fracture nearly plane.
Average for yellow clay					211.5	
August 10	T11	17.0 by 17.0	2.01	515	256	Fracture convex up 4 in.
" 10	T12	17.0 by 17.0	2.01	185	92	Fracture nearly plane.
" 12	T13	17.0 by 17.0	2.01	275	137	Fracture convex up 4 in.
" 12	T14	17.0 by 17.0	2.01	630	314	Fracture convex up 4 in. Rained hard two nights before.
" 12	T15	17.0 by 16.87	1.49	555	277	Fracture convex 4 to 5 in.
" 13	T16	17.0 by 17.0	2.01	635	316	Fracture convex up 1½ in.
" 13	T17	17.5 by 17.5	2.12	335	157	Rained, no effect on T17. Fracture convex up 1½ in.
" 15	T18	17.5 by 17.5	2.12	510	240	No effect of rain, fracture plane.
" 15	T19	17.5 by 17.5	2.12	495	232	Fracture convex up 4 in.
" 17	T20	17.5 by 17.5	2.12	500	235	Fracture convex up 4 to 5 in. and granulated.
" 17	T21	17.25 by 17.5	2.10	560	267	Fracture plane and granulated.
" 18	T22	17.5 by 17.5	2.21	890	418	Fracture convex up 3 to 4 in.
" 19	T23	17.5 by 17.5	2.12	830	296	Fracture convex up 3 in.
" 26	T24	17.5 by 17.5	2.20	705	332	Fracture convex up, granulated.
Average for blue clay					255.0	

The preponderance of strength of the blue clay over the yellow, although evident, was not especially marked, and did not occur to the extent that had been expected. The yellow clay may be here regarded as formed through the product of oxidation of the deeper blue variety through the penetration of air from the upper surface or contained in ground-water. The ferrous salts of blue clay are thus changed to ferric through the addition of oxygen. The yellow clay was not as firm or as dense as the blue. It was not infrequently permeated by roots, worm holes, and fibers or small crevices, and the strength would be correspondingly decreased. Probably the falling off in strength of the blue clay over that which was expected from the character of the deep preliminary borings, however, was due to the fact that the blue strata, while originally 12 ft. below the upper surface, were, in fact, in a gravel pit from which material had been excavated in years past. (See Fig. 4.) Thus, the upper top soil, yellow clay, and some gravel having been removed, and the

actual depth to the plane of rupture being only about 4 ft., oxidation may already have been occurring through the downward seepage of ground-water already mentioned.

The denser the matter, other things being equal, the greater the resistance presented to deformation. Oak, for example, is both heavier and stronger than pine; dense concrete is heavier and stronger than a more porous variety; steel which receives many passes through the rolls is heavier and stronger than that receiving a few passes. It is to be expected that earths which have been compacted through the slow processes of time, in general, will be stronger than those less compact. What the investigators have sought to do is to show that as the stress curves for sands "spread out" over a sheet,* approximately as their weights per cubic feet, so other earths and clays in particular may follow this same law. Qualitatively, there is little doubt of this. The blue clay specimens, T22, T23, and T24, which were in the most compacted region of the blue-clay bed also were among those having the greatest tensile strengths. The blue clay in tension is relatively heavier and stronger than the yellow clay, just as the latter predominates in density and strength over the loams. In particular cases, however, various local factors apparently may change the general law.

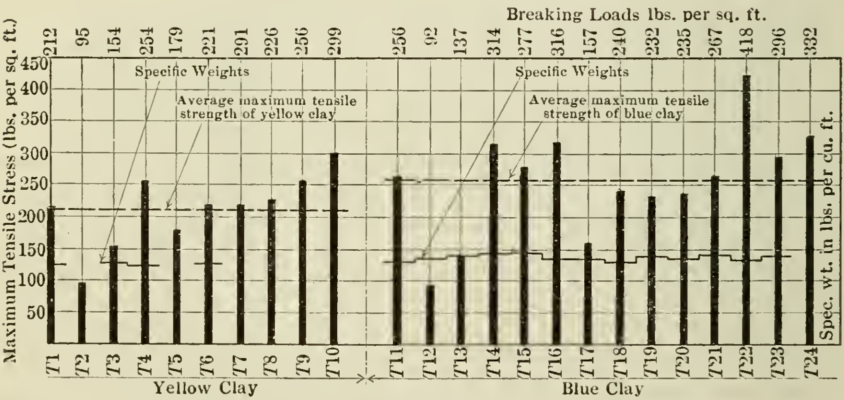


Fig. 6.

The methods used in obtaining the relative weights of the soils in place are described later. The values per cubic foot, as far as obtained, are platted to the same scale, but in different units, on Fig. 6. It will be noted that no parallelism or other visible relation which would indicate a quantitative law of correspondence is apparent. Dr. Sweeney expressed the opinion that the uncombined or hygroscopic water is a prominent factor to be considered and, undoubtedly, this is so. Sunbaked clay, of course, will be stronger than that existing after a flood. The water content is discussed later. One of the prominent factors appeared to be the friability or brittleness of the blue clay, as induced by the infiltration of water and air previously mentioned.

* See Figs. 24, 25, and 26, *Proceedings*, Am. Soc. C. E., Vol. XLVI (August, 1920), pp. 938–939.

which oxidizes the ferrous matter and causes the deposition of a brownish-yellow film along the planes of a separation which honeycombed the structure. A slight shock as a result of this film or matrix was often sufficient to leave the blue clay a coarse granular mass, and militated considerably at times against securing good compression and transverse specimens of the blue clay. Many of these points require further study. Smaller specimens more easily prepared and many of them undoubtedly are necessary in this work of correlation. The experimenters have under consideration other apparatus and further experiments along this line.

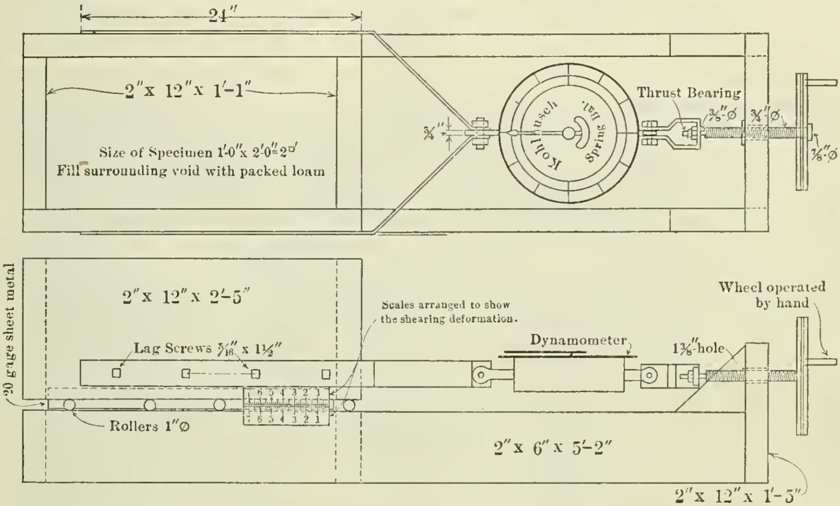


FIG. 7.

Discussion of Shear Tests

1.—Method of Procedure

(*a*).—*Preparation of Specimens.*—The shear specimens were obtained in much the same manner as the tensile specimens. The prisms were cut out of the solid to dimensions, 12 in. wide by 24 in. long by about 20 in. high. The wooden base frame of 2 by 6-in. fir, shown in Figs. 7 and 8, was placed over the specimen and the clearance space of about ½ in. was cased with black loam firmly packed into position. This acted much as moulders' sand when packed in a flask around a pattern. The upper box of 2 by 12-in. material was inserted in place and separated from the lower box by 1-in. rollers for the elimination of friction of the wood in the performance of the tests. Egress of the casing loam from this box was effectually prevented by stiff sheet-iron strips secured on the inside of the upper box on the front and sides and extended so as to seal the 1-in. space made by the rollers (entering the lower frame to a depth of about ½-in. on the sides only). A similar piece was placed on the lower frame at the rear. The specimen after thorough ramming of the casing material with a shingle strip was ready for the measuring apparatus. There is a slight increase of resilience over that of

the earth proper as a result of the contact with the wood, which could be obviated by taking larger areas, but, for practical purposes, this seems unnecessary.

(*b*).—*Method of Test.*—The dynamometer used on the tensile tests was utilized for measuring the shearing resistance. This dynamometer was inserted, and power was applied through the crank and screw at the right. Deformations along the surface of shear were measured by two scales placed in juxtaposition, one on the lower and the other on the upper frame, as indicated on Fig. 7. One observer applied the loads and read the dynamometer, while another read the movement on the scale. A light pressure of the hand downward applied to the rim of the upper box at the end prevented any tendency to uplift, which sometimes occurred. This can be corrected by lowering the steel bars on the upper frame. The rollers eliminated the friction between the wood, as has been stated.

TABLE 3.—Shearing Tests of Clay and Loam.

(Apparatus Shown in Figs. 7 and 8.)

Date of test.	Soil.	Serial number of specimen.	Dimensions at fracture, in inches.	Area, in square feet	Shearing load at rupture, in pounds.	Shearing stress at rupture, in pounds per square foot.	Remarks on fractures.
July 12.....	Sandy loam.	S 1	12.00 by 24.00	2.00	705	353	Nearly plane.
" 12.....	"	S 2	12.00 by 24.00	2.00	580	290	" "
" 13.....	"	S 3	12.00 by 23.25	1.94	570	294	" "
Average for sandy loam						312	
	Yellow clay.	S 4	11.38 by 24.75	1.96	1 080	552	Nearly plane.
July 16.....	"	S 5	12.25 by 24.62	2.09	1 340	640	Machine broken at this value.
August 3..	"	S 6	12.00 by 24.00	2.00	1 170	585	Nearly plane on fracture.
" 3..	"	S 7	12.00 by 24.25	2.02	1 050	520	Slightly conchoidal.
" 4..	"	S 8	12.00 by 24.00	2.00	1 390	695	" "
" 4..	"	S 9	11.87 by 24.50	2.02	1 400	694	Concave down, not well defined.
" 5..	"	S10	11.00 by 24.00	1.83	1 000	545	Slightly conchoidal.
" 9..	"	S11	12.00 by 24.00	2.00	880	440	" "
Average for yellow clay........					1 164	584	
August 10.	Blue clay	S12	12.00 by 24.00	2.00	790	395	Granulated.
" 19.	"	S13	12.00 by 24.00	2.00	730	365	Convex up and granulated.
" 19.	"	S14	11.00 by 23.00	1.76	840	477	Poorly defined, granulated and perhaps crushing.
" 19.	"	S15	12.00 by 24.00	2.00	760	380	Poorly defined, granulated and perhaps crushing.
" 22.	"	S16	12.00 by 24.00	2.00	970	485	Granulated.
" 25.	"	S17	11.50 by 24.00	1.91	810	422	Typical granular fracture.
" 26.	"	S18	11.00 by 24.00	1.83	780	426	Typical granular fracture.
" 26.	"	S19	12.00 by 24.00	2.00	735	367	Plane fracture more or less granular.
	"	S20	12.00 by 24.00	2.00	1 035	517	Plane, granulated.
Average for blue clay........						426	

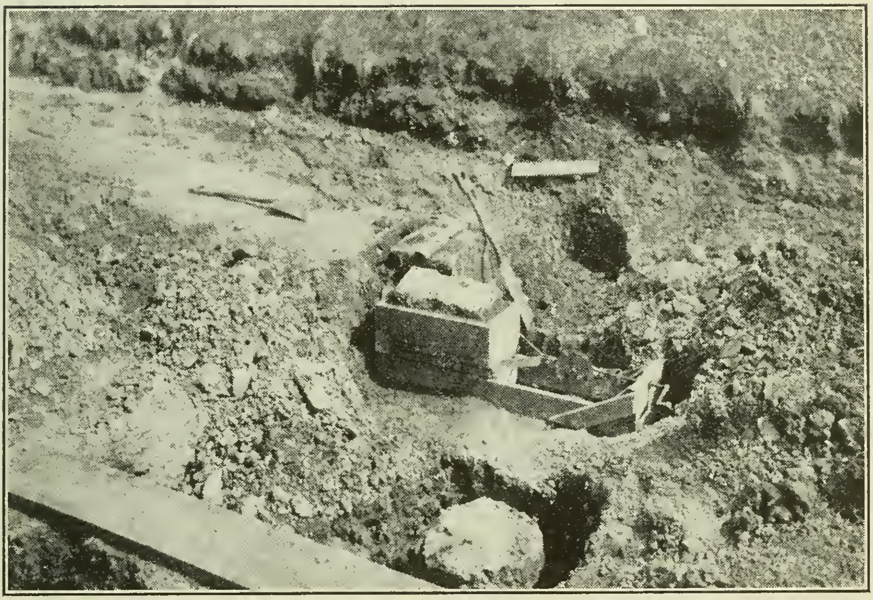


Fig. 8.—Specimens Ready for Test.

2.—Results of Shearing Tests.

The force exerted tangentially by the screw on the upper box and measured by the dynamometer is resisted by the fixed part of earth in the lower box. The maximum force, as observed by the pointer, divided by the area at the plane of separation (which was at or near the plane of the rollers, this area being about 2 sq. ft.), gives the shearing stress in pounds per square foot. The loads were applied at a nearly uniform rate, and the deformations were determined at stress increments of from 50 or 100 lb. The maximum shearing strengths observed for sandy loams, yellow and blue clays are given in Table 3 and Fig. 9 the latter being a graph of the results of the former.

It will be seen from Table 3 and Fig. 9 that the yellow clays had the greatest shearing resistance. The range of values extending from 440 to 695 lb. per sq. ft., with an average of 584 lb. The blue clays are next with a range of 365 to 517 lb. per sq. ft., and averaging 426 lb. The sandy loams range from 290 to 353 lb. per sq. ft., and average 312 lb. The loams had the better defined shearing surfaces which may be described as conchoidal, being not unlike the tensile tests. The yellow clays are next in clear definition. The blue clays tended to be more or less granulated, probably on account of the friable character of the clay examined due to the causes mentioned. It is, of course, quite safe to say that the deeper strata of blue clays, unaffected by ground-water and oxidizing elements, will possess considerably greater strengths than those given. In fact, the dried blue clays were extremely hard like shale. Doubtless, the upper limit of 800 lb. per sq. ft. in tension given by Airy was for very dense blue clay.

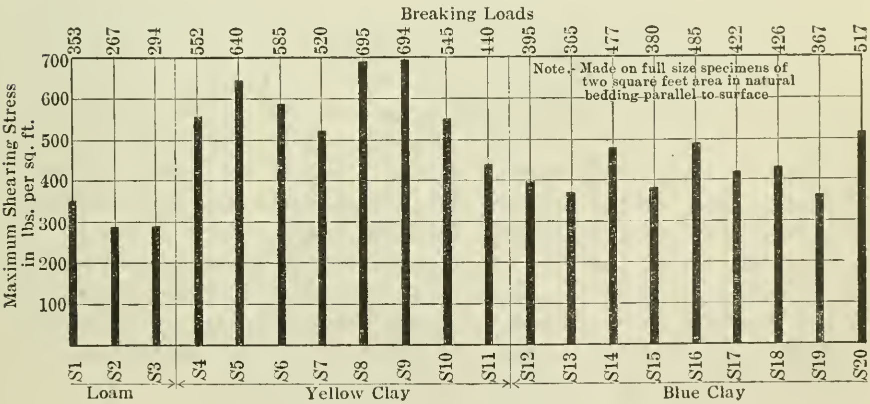


FIG. 9.

The results of the deformation data for yellow and blue clays are recorded in Table 4. They are almost precisely similar to those platted for compression in Figs. 10, 11, and 12, and have not been platted. Those for the sandy loams are also of the same type. It will be noticed that the curves do not follow those for elastic materials.

TABLE 4.—SHEARING DEFORMATION YELLOW AND BLUE CLAY.

Type of clay.	Shearing load, in pounds.	NUMBER OF SPECIMEN, AND SHEARING DEFORMATION, IN INCHES.					
		S4	S5	S7	S9	S10	S11
	0	0	0.00	0.00	0.00	0.00	0.00
	50	0	0.00	0.00	0.00	0.01	0.00
	100	0.02	0.05	0.02	0.02	0.02	0.01
	160	0.03	....	0.12	0.05	0.02	0.03
	250	0.05	0.10	0.17	0.08	0.04	0.05
	280	0.06	....	0.20	0.11	0.06	0.08
	325	0.10	0.15	0.23	0.12	0.10	0.11
	380	0.14	....	0.26	0.14	0.13	0.14
Yellow clay......	430	0.18	....	0.30	0.18	0.23	0.18
	490	0.22	....	0.34	0.20	0.29	0.22
	570	0.26	0.28	0.36	0.24	0.36	0.26
	600	0.29	....	0.39	0.28	0.39	0.30
	650	0.34	0.35	0.43	0.29	0.44	0.33
	705	0.36	....	0.46	0.31	0.48	0.37
	810	0.44	....	0.53	0.38	0.62	0.47
	970	....	0.55	1.00	0.48	1.00	....

Type of clay.	Shearing load, in pounds.	NUMBER OF SPECIMEN, AND SHEARING DEFORMATION, IN INCHES.				
		S12	S13	S14	S15	S16
	0	0.00	0.00	0.00	0.00	0.00
	50	0.01	0.02	0.03	0.00	0.02
	100	0.01	0.05	0.04	0.01	0.05
	160	0.02	0.09	0.09	0.01	0.11
	250	0.03	0.11	0.16	0.02	0.15
	280	0.05	0.16	0.20	0.04	0.20
	325	0.08	0.19	0.27	0.08	0.25
Blue clay.........	380	0.09	0.23	0.29	0.10	0.30
	430	0.11	0.29	0.37	0.14	0.36
	490	0.15	....	0.42	0.20	0.43
	570	0.19	0.38	0.48	0.25	0.50
	600	0.22	....	....	0.29	....
	650	0.27	0.46	0.57	0.36	0.59
	705	0.38	....	....	....	0.67
	760	....	....	0.70	....	....

NOTE.—These readings are the relative movements, in inches, of one scale of Fig. 7 on the other.

It will be clear that the shearing strengths which have been determined, are the initial shearing cohesions of the earth according to the hypotheses advanced by Bell,* Cain,† and other authorities, that is, they correspond to the intercepts on the vertical axis in Figs. 6 to 17 of a preceding report‡ of the Soils Committee, Appendix A, as determined in the Bureau of Standards tests. More strictly, the shear may be regarded as that corresponding to the initial stress plus the friction developed under about 1 lb. per sq. in., or 144 lb. per sq. ft., since this was approximately the quantity of earth above the surface of detrusion. It was thought to be advisable to carry on a series of tests according to this method, placing the earth under further compression by loading it with 50-lb. weights to different increments, and measuring the additional strength gained and the coefficient of friction.

DISCUSSION OF COMPRESSION TESTS

1.—Method of Procedure

Considerable difficulty was experienced in obtaining compression tests specimens on account of the brittleness of the clays and their tendency to disin-

* *Minutes of Proceedings*, Inst. C. E., Vol. 199 (1916), pp. 233–266.

† "Earth Pressures, Retaining Walls, and Bins", 1916, p. 5.

‡ *Proceedings*, Am. Soc. C. E., Vol. XLVI (August, 1920), pp. 923–929.

tegrate during the "sculpturing" of the samples. A carpenter's chisel frequently sharpened was found to be the best tool for cutting cylinders to form. As soon as the specimens were cut to shape, they were coated with a film of hot paraffin which served to protect them so that they could be transported to the laboratory for test. This film was about $\frac{1}{64}$ in. thick and was applied by quickly dipping the specimen in a pan of the paraffin which was heated over an alcohol lamp. The heat of the sun was sufficient to melt the paraffin, so the latter had no appreciable effect on the specimen, but formed the thin coat immediately on contact with the clay. This film corrected a tendency to superficial disintegration and accordingly prevented integral failure in handling in a large degree, for if matter fails, it must have space to fail, and this is prevented by the film. The cylinders were then carefully packed in loam for handling. The ends were capped with plaster of Paris, as in the case of concrete cylinders.

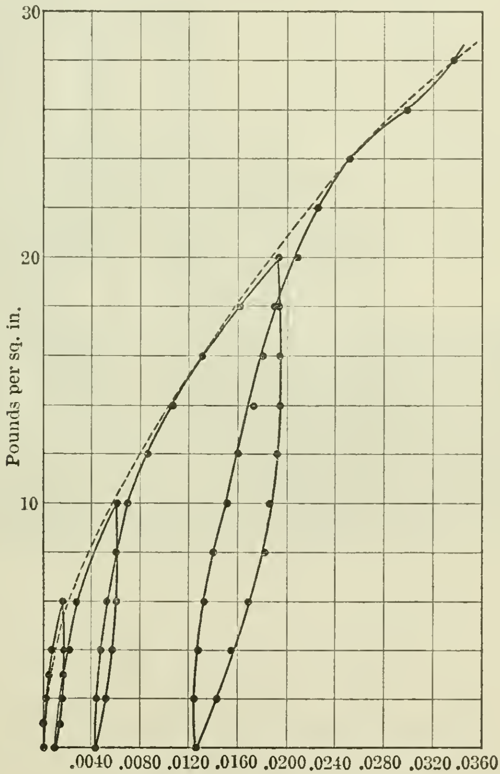


FIG. 10.

The tests were conducted in a 60 000-lb., Olsen, 4-screw, machine (Fig. 13). The only mechanical detail needing a brief description are the extensometers. These were conveniently made of three Ames dials reading to 0.001 in. and having travels of spindles of 1 in. fastened to the pins of a "drill rod" of the size of a knitting needle, which were stuck in the clay at 120° apart about the axis of a cylinder.

The dial spindles were in contact with short gauge-rods similarly connected to the clay by pins. The spindles of the gauges were held taut against the gauge-rods by rubber bands. These gauges gave good satisfaction and are recommended for field use.

FIG. 11.

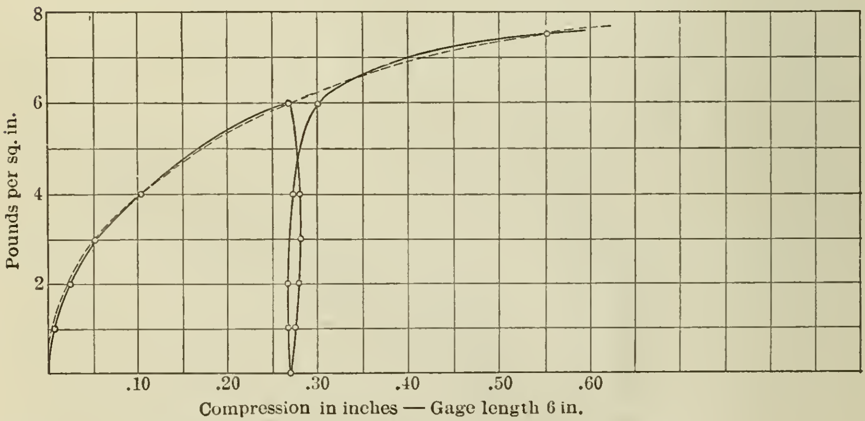


FIG. 12.

2.—Discussion of Results.

(*a*).—*Maximum Loads.*—The observed maximum loads, in pounds per square inch and pounds per square foot, are shown in Fig. 14. The average for the yellow clay 28.5 lb. per sq. in., exceeds that of the blue clay 17.2 lb. per sq. in., by about 66 per cent. The characteristic failure was usually by bulging of walls, as in the case of lead cylinders, accompanied by "spawling off" of the outer layers. Several of the yellow clay cylinders failed by shear-

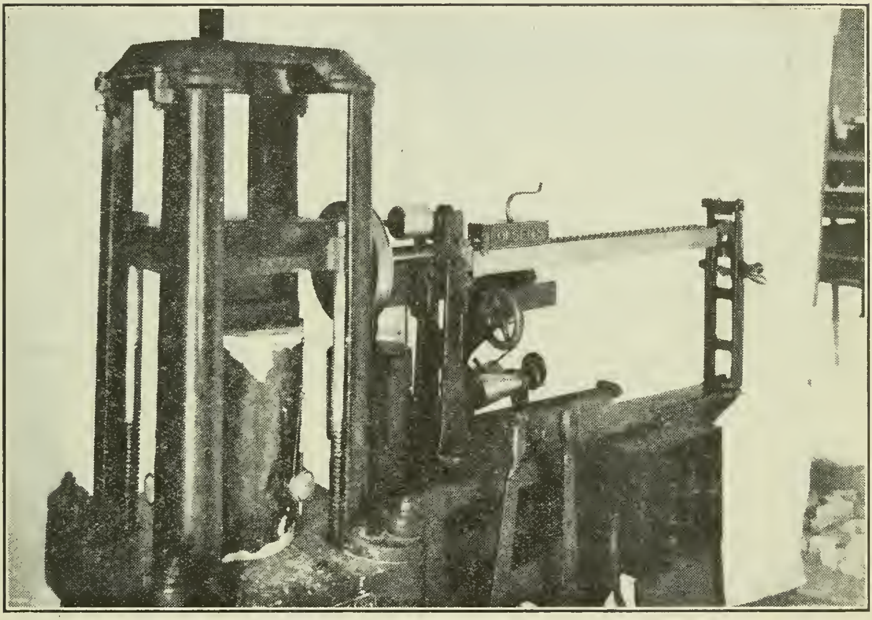


FIG. 13.—CLAY CYLINDER IN COMPRESSION TEST.

ing "clean off" on an inclined plane, as in the case of some concrete column and cylinder tests.

TABLE 5.—COMPRESSION TESTS OF CLAY.

(Apparatus shown in Fig. 13.)

Date of test, 1921.	Soil.	Serial number of specimen.	Dimensions, in inches, diameter by length.	Sectional area, in square inches.	Observed maximum load, in pounds.	MAXIMUM OBSERVED STRESS: Pounds per square inch.	Tons of 2 000 lb. per sq. ft.	Remarks on fractures.
August 2.	Yellow clay	C 3	6.84 by 11.0	36.8	1 080	29.4	2.12	Sides bulged out.
" 2.	Yellow clay	C 4	4.97 by 6.50	19.4	800	41.2	2.97	....
" 18.	Blue clay	C 5	7.71 by 9.12	46.7	630	13.5	0.97	Sides bulged out.
" 20.	Blue clay	C 6	7.61 by 10.50	45.5	425	9.3	0.67	Bulged at center, softer within.
" 24.	Yellow clay	C 7	8.0 by 8.75 square, by 15	70.0	1 080	15.4	1.11	Failed in shear, smooth inclined fracture.
" 25.	Yellow clay	C 8	8.30 by 9.5	54.1	1 920	35.5	2.56	Started to fail in shear, bulged one side.
" 26.	Yellow clay	C 9	8.67 by 14.25	59.0	1 298	22.0	1.58	Shearing failure one side, bulged on other.
" 26.	Yellow clay	C10	9.03 by 14.62	64.0	2 030	31.7	2.28	Diagonal plane in shear through specimen.
" 27.	Blue clay	C11	9.03 by 8.25	64.0	2 250	35.2	2.54	Side bulged out.
" 27.	Blue clay	C12	9.12 by 10.25	65.2	700	10.7	0.77	Cracked and bulged out near bottom.
" 27.	Yellow clay	C13	9.12 by 14.25	65.2	1 550	23.8	1.72	Diagonal fracture and bulging on opposite side.
" 30.	Yellow clay	C14	8.90 by 14.50	62.3	1 800	28.9	2.09	Diagonal fracture and bulging on opposite side.
Average for yellow clay................................						28.5	2.05	
Average for blue clay................................						17.2	1.24	

(*b*).—*Flow of Clay Under Low Loads.*—Specimen C3 was subjected for 7 hours to a continued loading amounting at its maximum to only 5.44 lb. per sq. in., or less than one-fifth the breaking load (29.4 lb. per sq. in.). The results are given in Table 6, and show that throughout this entire period, the specimen continued to yield gradually under the pressure. This experiment* is interesting and is possibly a valuable line of future research to determine the limits of the loads which clays containing different percentages of moisture can carry indefinitely without dangerous settlement.

(*c*).—*Typical Stress-Strain Curves.*—A number of stress-deformation curves were carried out in detail for the clays. The data given in Tables 7, 8, 9, and 10 are typical.

It will be noticed (Figs. 10, 11, and 12) that the stress is not a linear function of the compression. The deportment, moreover, is such as to lead one to believe that the time of loading in tests must be a prominent factor. Second, the loops in the diagrams show the presence of pronounced hysteresis

* Undertaken after reading *Sir* Joseph Larmor's discussion, *Minutes of Proceedings*, Inst. C. E., Vol. 199 (1914–15), pp. 321–323, of Bell's paper on the "Lateral Pressure of Clay."

phenomena. To illustrate, on the first run from zero to 6 lb. per sq. in., in the case of Specimen C5, Fig. 11, a certain amount of strain energy is put into the specimen, this being proportional to the area under the curve. On going back to zero from 6 lb. per sq. in., only a small part of the applied energy is given back, probably owing to flow and easement within the structure of the clay during the intervening time. A large set of 0.0081 in. exists. The operations were repeated with several applications and reversals. In the case of Cylinder C5, three loops are obtained. These loops may be compared with those for similar curves for sand given in a preceding progress report* of the Committee.

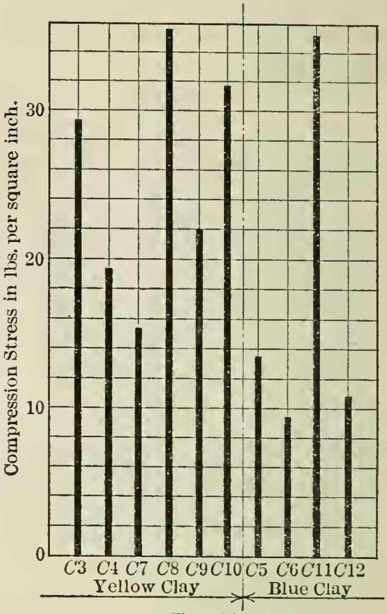


Fig. 14.

TABLE 6.—Time-Strain Test Showing Rate of Flow for Yellow Clay, July 26th, 1921.

Specimen C3 cut from solid; Extensometer and Load Applied; Mean Diameter of Specimen = 6.84 in.; Area = 36.8 sq. in.; Height = 11 in.; Surface paraffined and ends capped with plaster of Paris.

Log of Tests, Temperature 85° to 86° Fahr.

Load applied, in pounds.	Time of observation, 10:30 A.M. + min.	Three Ames Dial Extensometers, Gauge, 6 In., Set 120° Apart, and Readings Taken at Times Shown:				Average cumulative compressive strain.
		S, in inches, tension.	E, in inches, compression.	W, in inches, compression.	Cumulative deformation of S. E. W.	
0	0	0.0408	0.0022	0.0472	0.00000	0.00000
50	0	0.0408	0.0037	0.0472	0.00050	0.00008
100	0	0.0398	0.0047	0.0472	0.00050	0.00008
150	0	0.0382	0.0062	0.0475	0.00057	0.00009
200	0	0.0345	0.0085	0.0522	0.00167	0.00028
200	15	0.0312	0.0105	0.0567	0.00273	0.00046
200	30	0.0294	0.0111	0.0586	0.00297	0.00050
200	45	0.0285	0.0113	0.0597	0.00310	0.00052
200	60	0.0277	0.0117	0.0603	0.00317	0.00053
200	75	0.0275	0.0117	0.0607	0.00323	0.00054
200	90	0.0268	0.0119	0.0614	0.00330	0.00055
200	150	0.0251	0.0127	0.0648	0.00413	0.00069
200	180	0.0242	0.0127	0.0657	0.00413	0.00069
200	210	0.0226	0.0128	0.0672	0.00413	0.00069
200	240	0.0222	0.0127	0.0677	0.00413	0.00069
200	270	0.0220	0.0127	0.0684	0.00437	0.00073
200	300	0.0218	0.0127	0.0692	0.00450	0.00075
200	330	0.0207	0.0127	0.0707	0.00463	0.00077
200	360	0.0202	0.0129	0.0711	0.00467	0.00078
200	420	0.0197	0.0129	0.0717	0.00470	0.00078
150	420	0.0203	0.0122	0.0720	0.00477	0.00080
100	425	0.0210	0.0119	0.0709	0.00453	0.00076
50	427	0.0227	0.0118	0.0688	0 00437	0.00073
0	430	0.0250	0.0100	0.0670	0.00393	0.00066

* *Proceedings*, Am. Soc. C. E., Vol. XLVI (August, 1920), p. 937, Fig. 23.

TABLE 7.—COMPRESSION SPECIMEN C3, YELLOW CLAY.
Diameter = 6.84; Area = 36.8 sq. in.; Height = 11 in.; Gauge Length = — 6 in.

Load, in pounds per square inch.	Load, total.	AMES DIAL READINGS.			Total compression, in inches.
		E.	S.	W.	
0	0	0.0235	0.0418	0.0452	0
1	37	0.0238	0.0418	0.0452	0.0001
2	74	0.0241	0.0418	0.0452	0.0002
3	110	0.0248	6.0419	0.0453	0.0005
4	147	0.0252	0.0422	0.0453	0.0007
6	221	0.0267	0.0437	0.0453	0.0017
4	147	0·0268	0.0439	0.0452	0.0018
3	110	0.0268	0.0439	0.0452	0.0018
2	74	0.0261	0.0441	0.0451	0.0016
1	37	0.0257	0.0441	0.0451	0·0015
0	0	0.0253	0.0438	0.0450	0.0012
2	74	0.0262	0.0438	0.0452	0.0016
4	147	0.0278	0.0438	0.0452	0.0021
6	221	0.0289	0.0445	0.0454	0.0028
8	294	0.0308	0.0460	0.0451	0.0038
10	368	0.0340	0.0481	0.0455	0.0057
8	294	0.0340	0.0483	0.0455	0.0058
6	221	0.0340	0.0483	0.0453	0.0057
4	147	0.0330	0.0483	0.0453	0.0054
2	74	0.0313	0.0481	0.0453	0.0047
0	0	0.0302	0.0470	0.0453	0.0040
2	74	0.0302	0.0468	0.0454	0.0040
4	147	0.0320	0.0468	0.0455	0.0046
6	221	0.0327	0.0471	0.0455	0.0049
8	294	0.0340	0.0482	0.0455	0.0057
10	368	0.0358	0.0492	0.0455	0.0067
10	368	0.0358	0.0492	0.0455	0.0067
12	442	0.0381	0.0510	0.0462	0.0083
14	515	0.0408	0.0528	0.0478	0.0103
16	588	0.0440	0.0549	0.0498	0.0127
18	662	0.0483	0.0581	0.0520	0.0160
20	736	0.0530	0.0609	0.0541	0.0192
18	662	0.0530	0.0611	0.0541	0.0192
16	588	0.0530	0.0611	0.0541	0.0192
14	515	0.0530	0.0611	0.0540	0.0192
12	442	0.0530	0.0606	0.0540	0.0190
10	368	0.0520	0.0596	0.0540	0.0184
8	294	0.0520	0.0589	0.0540	0.0181
6	221	0.0486	0.0588	0.0540	0.0170
4	147	0.0464	0.0579	0.0534	0.0156
2	74	0.0450	0.0568	0.0522	0.0145
0	0	0.0431	0.0553	0.0507	0.0129
2	74	0.0428	0.0548	0.0507	0.0126
4	147	0.0439	0.0547	0.0507	0.0129
6	221	0.0448	0.0550	0.0507	0.0133
8	294	0.0458	0.0563	0.0507	0.0141
10	368	0.0476	0.0579	0.0507	0.0152
12	442	0.0493	0.0591	0.0508	0.0162
14	515	0.0508	0.0600	0.0516	0.0173
16	588	0.0521	0.0610	0.0521	0.0182
18	662	0.0538	0.0618	0.0529	0.0193
20	736	0.0557	0.0633	0.0541	0.0209
22	810	0.0580	0.0650	0.0550	0.0225
22	810	0.0580	0.0650	0.0550	0.0225
24	884	0.0618	0.0680	0.0568	0.0254
26	957	0.0688	0.0729	0.0592	0.0301
28	1 030	0.0900	0.0881	0.0642	0.0439
29.4	1 080	Maximum stress; failure by sides buckling outward.			

TABLE 8.—COMPRESSION TEST C5, BLUE CLAY, AUGUST 18TH, 1921.

Diameter: Top = $8\frac{3}{8}$ to $6\frac{7}{8}$ in.; Bottom = $8\frac{5}{8}$ and $7\frac{3}{4}$ in.; Mean Diameter = 7.71;

$$\text{Area} = \frac{c^2}{4\pi} = 46.7 \text{ in.}$$

Circumference at Center = $24\frac{1}{4}$ in.; Gauge Length = 5 in.; Height = $9\frac{1}{8}$ in.

Taken from under T16.

Load, in pounds per square inch.	Load, total.	Ames Dial Readings.			Total compression, in inches.
		E.	S.	W.	
0	0	0.0421	0.0561	0.0582	0
1	47	......	......	......	......
2	93.5	0.0432	0.0572	0.0601	0.0014
3	140	0.0457	0.0628	0.0617	0.0046
4	187	0.0481	0.0674	0.0637	0.0076
6	280	0.0521	0.0742	0.0682	0.0127
4	187	0.0521	0.0742	0.0682	0.0127
3	140	0.0516	0.0742	0.0681	0.0125
2	93.5	0.0500	0.0739	0.0681	0.0118
1	47	0.0479	0.0720	0.0670	0.0102
0	0	0.0458	0.0691	0.0658	0.0081
2	93.5	0.0460	0.0690	0.0654	0.0080
4	187	0.0508	0.0732	0.0674	0.0116
6	280	0.0532	0.0771	0.0700	0.0146
8	374	0.0596	0.0888	0.0794	0.0238
10	467	0.0650	0.1020	0.0930	0.0345
8	374	0.0646	0.1020	0.0935	0.0346
6	280	0.0626	0.1020	0.0930	0.0337
4	187	0.0582	0.1011	0.0928	0.0319
2	93.5	0.0541	0.0979	0.0890	0.0282
0	0	0.0492	0.0923	0.0831	0.0227
2	93.5	0.0500	0.0922	0.0829	0.0229
4	187	0.0538	0.0932	0.0857	0.0254
6	280	0.0573	0.0962	0.0887	0.0286
8	374	0.0602	0.0991	0.0908	0.0312
10	467	0.0666	0.1059	0.1011	0.0391
12	561	0.0718	0.1180	0.1209	0.0517
13.5	630	Maximum stress; failure by sides buckling outward.			

TABLE 9.—COMPRESSION TEST C6, BLUE CLAY.

Test, August 20th, 1921, Taken at One Side and Below T20

Diameter = 7.61 in.; Area = 45.5 sq. in.; Height = 10.5 in.;

Gauge Length = 6 in.

Load, in pounds per square inch.	Load, total.	Ames Dial Readings.			Total compression, in inches.
		E.	S.	W.	
0	0	0.0638	0.0529	0.0512	0
1	46	0.0702	0.0591	0.0568	0.0061
2	91	0.0878	0.0822	0.0807	0.0277
3	136	0.1018	0.0992	0.0978	0.0436
4	182	0.1479	0.1505	0.1540	0.0949
6	273	0.3035	0.3075	0.3308	0.2580
4	182	0.3035	0.3156	0.3538	0.2684
3	136	0.3035	0.3143	0.3530	0.2676
2	91	0.3021	0.3108	0.3522	0.2658
1	46	0.2990	0.3068	0.3492	0.2624
0	0	0.2940	0.3021	0.3450	0.2578
2	91	0.2940	0.3012	0.3450	0.2574
4	182	0.2989	0.3028	0.3503	0.2614
6	273	0.3218	0.3318	0.3788	0.2882
7.59	346	0.5592	0.5392	0.7083	0.5463
Max. 9.34	425	......	......	......	......

TABLE 10.—COMPRESSION TEST NO. 9, YELLOW CLAY, AUGUST 26TH, 1921.
(See Fig. 13.)

Circumference: Top, 27 in.; Center, 27⅜ in.; Bottom 27¼ in.; Average 27¼ in.; Diameter = 8.67 in.; Area = 59.0 sq. in.; Height = 14.25 in.: Gauge Length = 6 in.

Load, in pounds per square inch.	Load, total.	Ames Dial Readings.			Total compression, in inches.
		E.	S.	W.	
0	0	0.0724	0.0693	0.0413	0
1	59	0.0739	0.0710	0.0419	0.0013
2	118	0.0753	0.0726	0.0423	0.0024
3	177	0.0775	0.0737	0.0442	0.0041
4	236	0.0790	0.0770	0.0463	0.0064
6	354	0.0846	0.0856	0.0520	0.0131
8	472	0.0899	0.0930	0.0576	0.0192
10	590	0.0940	0.0991	0.0638	0.0246
12	708	0.0979	0.1051	0.0691	0.0297
14	826	0.1021	0.1100	0.0738	0.0343
16	944	0.1068	0.1167	0.0812	0.0406
18	1 052	0.1089	0.1212	0.0853	0.0441
20	1 180	0.1116	0.1279	0.0912	0.0492
Max. 22	1 298	0.1131	0.1328	0.0953	0.0527

APPENDIX V

REPORT ON WORK OF BUREAU OF PUBLIC ROADS IN INVESTIGATION OF SOILS

BY A. T. GOLDBECK, ASSOC. M. AM. SOC. C. E.

The Bureau of Public Roads is interested in researches in connection with soils, because of the influence of soil characteristics on the design of highways and highway structures. During the past decade, wheel loads have increased in weight, and, in the past four years, particularly in the spring of 1917, a large number of road failures occurred in which the road surfaces were destroyed, either as a whole or, in a number of localities, due to a combination of heavy loads and soft sub-grades.

It was demonstrated by these failures that soils have widely varying supporting properties, depending on their physical characteristics and on the amount of moisture present, and studies are now being made in the laboratory of the Bureau of Public Roads to determine the physical characteristics of soils which have influence on their bearing value.

Results of tests made on samples of soil are now being accumulated and, after a sufficient number have been obtained and analyzed, it is possible that the investigators will be able to describe the soil in terms of its physical characteristics so that it will be possible to make use of these characteristics in their control of the design of highway structures.

In order to correlate the laboratory characteristics of soils with their field behavior, samples have been selected from various roads throughout the United States from spots that have failed and from spots that have remained intact. The surrounding influences contributory to the failure have been recorded and the samples subjected to the laboratory tests. In this way, it is hoped to correlate field behavior with physical characteristics.

In connection with the study of rational methods for the design of road surfaces, some investigation has been made of the distribution of pressure between the sub-grade and the road surface, and it is contemplated that much more complete investigations of this character will be carried on in the future. It will readily become apparent that the design of the road surface is greatly influenced by the supporting properties of the sub-grade, and for this reason it is important to determine not only the bearing value and other physical characteristics of the sub-grade material, but it is also important to determine the distribution of pressure through various thicknesses of slabs to the various kinds of sub-grades under known concentrated loads. Studies of this character are being pursued with the use of the soil pressure cell. It is contemplated that results of these investigations will be available during the coming year.

Adsorption Test.—This test has been developed by Dr. E. C. E. Lord, of the Bureau of Public Roads, to determine the adsorption properties of soils for basic aniline dye, as a measure of the plasticity and bearing power of sub-grade road materials, and is carried out on material passing the 200-mesh sieve and on the silt, clay, and ultra clay obtained by the mechanical analysis from 25 grammes of soil.

The dye solution used in this test consists of 1 part per 1 000 of crystal violet in distilled water, and a sufficient quantity should be made up in advance to assure a constant strength for a large number of tests.

The test is carried out, as follows: A sample of the soil weighing 0.20 gramme is transferred by means of a wide-necked funnel to a cylindrical separatory tube with a capacity of about 5 cu. cm., containing about 1 cu. cm. of the solution, and is there thoroughly stirred with a platinum or polished brass rod until the solution is completely decolorized and the coagulated clay sinks to the bottom of the tube. It is then run into a filtering tube closed at one end with filter paper, and the separatory washed clean with a few additional drops of the solution. This filtering tube should measure about 6 in. by ½-in. inside diameter and be drawn at the lower end for a distance of 1 in. to a stem having a ¼-in. inside diameter, into which a ground-glass stopper tube is inserted to hold the filter paper firmly in place and assure an even flow of the dye solution through the material to be tested and should be filled with water before the beginning of the test.

The filter tube containing the flocculated clay sample is inserted in a 25-cu. cm. graduate and allowed to drain, when additional dye is added and the filtration continued until a strong coloration appears in the liquid immediately below the filter paper, when the volume of decolorized solution is noted in the graduate.

The test for silt, clay, and ultra clay is carried out in the same manner, except in the case of the ultra clay where the quantity of material obtained is usually very small, requiring a more dilute dye solution (1 : 5 000).

The results of the tests are recorded in cubic centimeters of dye adsorbed for unit values (1 gramme) of the silt, clay, ultra clay, and the sample as a whole, as well as for the proportional quantities of those materials found by mechanical analysis.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

DISCUSSION ON TENTATIVE SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE*

SUBMITTED AS A PROGRESS REPORT OF THE JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE†

* Presented at the meetings of December 7th and 8th, 1921. Since this discussion was primarily for the consideration of the Joint Committee, much of it has been deleted for publication.

† *Proceedings*, Am. Soc. C. E., August, 1921, p. 59.

WATER-PROOFING AND PROTECTIVE TREATMENT. SURFACE FINISH.

By Messrs. Philip Marquand, J. B. W. Gardiner, A. H. Rhett, B. A. Howes, S. E. Stott, Elwyn E. Seelye, George L. Lucas, A. Burton Cohen, Lewis Jerome Johnson, F. C. Wight, H. W. Hobbs, Charles C. Hurlbut, A. T. Malmed, D. H. Dixon, Walter F. Ballinger, G. Harrisson, and Herbert W. Goddard.

Philip Marquand,* Assoc. M. Am. Soc. C. E. (by letter).†—In several places in the Tentative Specifications for concrete is mentioned the placing of neat cement on the wet surface of old concrete to be bonded with new concrete, as, for instance, in Section 95. It is not stated whether the neat cement is to be dry or is to be a thick grout, unless the word, neat, precludes a mixture with water. It has been the writer's experience that a thick neat cement grout, placed on the damp surface of the old work with a brush, is better than sprinkling the wetted surface with dry cement, as is often done. The grout is evenly mixed and evenly laid with the brush.

The dry cement on the wet surface is not properly mixed with the moisture of this surface and there are parts of it that never get wet, even after the concrete is placed. At best, it is not of even thickness.

J. B. W. Gardiner,‡ Assoc. M. Am. Soc. C. E.—There are only two ways of specifying water-proofing materials—either by trade name or by properties and characteristics. Both the water-proofing industry and the Engineering Profession have suffered from the trade name fetish. The idea behind it is that it would serve as a guaranty of quality; but it does not. Water-proofing manufacturers frequently change their materials for economic rather than quality reasons; but always their materials carry the same trade name.

The great advances that have been made during the past ten years, and particularly since 1915, in the extraction of by-products from gas and coke-oven tar, have left the pitch an entirely different material from that on which all service records are based; so that past performance gives no clue to future efficiency. The net results are that, if good materials are to be obtained, past records and trade names must be heavily discounted, and entire reliance must be placed on carefully drawn and strictly adhered to specifications.

The science of water-proofing production is well known; the processes used are few and simple, and, at least in the case of asphalt, given the base material and a knowledge of how it is made, it is entirely possible to predetermine from standard tests how a given material will act.

That there is a growing necessity for an adequate water-proofing specification is recognized by the American Society for Testing Materials, which has had a committee—Committee D8—engaged on this work for a number of

* Chf. Engr., Edge Moor Iron Co., Edge Moor, Del.

† Received by the Secretary, December 8th, 1921.

‡ Pres., Gardiner & Lewis, Inc., New York City.

years. Without desire to belittle the importance of the work done, nothing definite, as far as the speaker knows, has been accomplished.

If engineering is as exact a profession as it is thought and is claimed to be, a material that has such an important function to perform should be selected on a more intelligent basis. Emphasis is added to this by the fact that water-proofing has not been standardized like cement and steel. The vast volume of these materials that were being used, early disclosed the necessity for standardization. Exhaustive studies have been made by various scientific bodies with this end in view and there have been evolved specifications which set a standard to which such materials must conform to be acceptable. This is not true of water-proofing, and if the manufacturers can prevent it, it never will be true. It is only a question of how long American engineers will continue to buy something merely because some one has it to sell and not because of the basic merit it possesses.

A. H. Rhett,* Assoc. M. Am. Soc. C. E.—The results obtained by the speaker on a number of structures did not seem to warrant any such dictum as that "integral compounds shall not be used".

Thin concrete sections subject to wide temperature variations, vibration, or impact, will crack, and the water-proofing problem is one of water-proofing cracks. Obviously, the only way to effect this result is to protect the cracks with a membrane or coating elastic enough to span them. In a deep foundation and wet excavation, where a water-proofing is required and where conditions preclude the use of a membrane, it would be obviously desirable to use integral water-proofing. Furthermore, it is being recognized that concrete is not permanent unless water-proofed.

In any effort to render concrete or mortar intrinsically water-proof, it must be borne in mind that water enters in two ways, namely, by absorption through minute pores and by percolation through pores of appreciable size. Taking cognizance of these facts, water-proofing materials seem to have been produced mainly on two theories: (1) water-repellent materials; and (2) water absorbent and lubricating materials. The first are designed to kill absorption, the second to eliminate porosity.

As far as mortars and stucco are concerned, the first theory seems to be entirely rational, because the mortar consists of finely particled materials, applied under pressure, and, therefore, there are no voids and water enters, chiefly, through absorption.

As regards concrete there is, however, room for difference of opinion. The water-repellent theory assumes that if the mortar is rendered non-absorptive, the concrete is water-proof because the coarse aggregate does not absorb. The lubricating and water absorbent theory holds that as the mortar is only a small part of the volume, absorption is a minor factor and that the elimination of permeability through the elimination of porosity is the end to be accomplished. Porosity is due largely to too much water, too little tamping, too vertical chuting, insufficient mixing, segregation of material, and insufficient absorption of the water by the cement. If the lubricating

* Gen. Sales Mgr. and Engr., Toch Bros., New York City.

element can be introduced, the liability to defects from superfluous water, insufficient tamping, and vertical chuting is certainly lessened. If absorption of the water by the cement can be increased, accompanied by a slight swelling action, the liability to porosity from the evaporation of unabsorbed water is lessened.

It is possible to test in a laboratory the absorption killing effect on mortars, but nullification of field errors cannot be tested until laboratory experiments can reproduce the field errors. It is difficult to see, too, on what basis the result of a laboratory experiment can be considered more convincing than results obtained in field operations. Most certainly results obtained in field operations have convinced a large number of practical users of the value of integral compounds when properly used.

To the speaker's knowledge, however, no really authentic and comprehensive laboratory tests have ever been made. Much has been made of the tests conducted by the Bureau of Standards in 1911 and their generally assumed adverse findings. As carefully as these tests were made, a detailed examination does not substantiate this assumption. For instance, on page 64, the following statement occurs, referring to the results of the tests as applied to a 1:4 sand mortar, after four weeks immersion: "It will be observed that all of the mortars containing water-repellent compounds were damp-proof". And Table 19 shows further that although the untreated specimens failed after 58 days, three specimens containing water-repellent compounds were sound after, respectively, 110, 136, and 164 days. It would also no doubt surprise many to know that the tests did not even include concrete, but were made solely on mortars. In no other factor pertaining to good concrete would it be considered valid to reason from mortar to concrete in view of present knowledge, and certainly, as it was attempted to show, it is not valid to do so in regard to water-proofing.

It can no longer be disputed that the entrance of water into concrete is destructive of its permanence, that means must be produced to exclude it, and that the means suitable for one condition may not be applicable for another.

B. A. Howes,* M. Am. Soc. C. E.—The explanation given of how the water-proofing is attained by the coating of capillaries would be of great scientific interest if backed by laboratory demonstration. The description of results on work are impressive to the practical man unless he realizes that all the results claimed for integral water-proofing have been duplicated without its use, at no greater expense, by careful workmanship and rich mixtures.

Concrete of antiquity, built before the Christian era, and similar to modern concrete, is in a good state of preservation; in some cases even with the board marks on it, as the baths of Caraculla. The roof of the Pantheon, still intact, is a dome of concrete spanning 150 ft. There is no reason to believe integral water-proofing was used on these. If scientific demonstration could be made of how the compounds effect their supposed result, it would,

* Cons. Engr., New York City.

if favorable to their use, go far to help the Profession to attain greater permanence in exposed construction.

The theory that water penetrates concrete through capillaries similar to the laboratory capillary tube has not been demonstrated as far as the speaker knows. He has searched for them in fragments and very thin sections of old and of new concrete under the high-power microscope and found only voids, segregation, and cracks.

The compounds are usually (except in the case of lime) organic compounds or based on organic compounds and, therefore, it is natural to distrust their life and integrity over a long term of years until sound proof is produced for it.

The speaker believes that the Society should not provide for the possibility of a future scientific development in its specifications. The case of integral water-proofing may be stated as not proven. Other speakers have indicated that another cement medicament is developing. Undoubtedly, all engineers will receive these developments with appreciative attention, and when pioneers shall have demonstrated them on their special problems, it will be time enough to open the specifications to provide for their general use by non-technical workers, builders, and architects.

The proposals to bring about a more rapid hydration of a greater proportion of the cement particles, whether by fine grinding or otherwise, should be accepted with caution. The speaker is doubtful whether it would be good policy in ordinary concrete work completely to hydrate the cement. He has found under the microscope particles of cement, 0.005 to 0.001 in. in size, that had remained unhydrated in work for five years. Those particles were ready to do their work, if called on, perhaps through the readjustment of a strain, or the stoppage of a slow penetration of water.

Any such broad development as has been suggested, that might take place, in the matter of integral water-proofing, would require probably a long time to determine whether it was a detriment or a benefit over the period of years that one has to expect for structures, and in that time there would be plenty of opportunity to change the specifications that govern its use.

The speaker was especially struck by the suggestion that an additional material, especially in small quantities, has a psychological effect on the workers. That is true as long as the novelty lasts, but concrete workers are practical men. The only help that could be looked for along these lines would be in the use of some kind of coloring material.

As to bituminous water-proofing, the fabric, paper, or fibrous felt which is used to restrain the layers of bituminous compound from flow, is readily susceptible to mechanical or chemical tests for the purposes in view, and may easily be standardized for recognized uses.

The bituminous materials, however, as Mr. Gardiner has brought out, are constantly changing. In no brand is the user assured of the same material year after year, except in the case of some natural deposits of great extent like Trinidad Lake, because the original new material varies; it comes from gas-works, petroleum wells, weathered oil storages, and is the end or intermediate product of various distilling, cracking, or oxidizing processes, accord-

ing as the demand for gasolene, kerosene, benzol, and toluol determines the most profitable treatment of the raw materials; so that a certain molecular constituent which may be a very valuable constituent as to long life for one bituminous product, may not be found in the oil or cracked residue from a well, coal, or deposit in another part of the world, although the two bituminous products may coincide by standard tests. In the present state of the art, it is beyond the possibilities of this Committee to cover bituminous water-proofing compounds. Only a joint committee representing the engineering, chemical, oil, asphalt, and water-proofing interests could constructively deal with bituminous water-proofing compounds.

S. E. Stott,* Assoc. M. Am. Soc. C. E.—The speaker's experience has proven that there are other methods of water-proofing concrete structures as satisfactory and effective as a membrane method. A case will be cited where a method other than the membrane was used to overcome a serious condition in a concrete stand-pipe and satisfactory results were obtained.

The stand-pipe is 30 ft. inside diameter at the base and 105 ft. high, and was built 10 or 12 years ago by a competent engineering and contracting firm. The thickness of the walls at the base is 28 in. and at the top only 12 in. Immediately after the tank was completed, leaks developed through the construction joints, which were 3½ ft. apart, the entire height of the tank. The water from these cracks ran down the outside of the tank and saturated the concrete. During cold weather, the water froze, which caused the concrete to spall off in large areas, some of which were 20 ft. high, 13½ ft. across, and 8 in. thick, thereby exposing the steel reinforcement of the tank. J. R. Worcester, M. Am. Soc. C. E., was called in to make a thorough examination of the tank and to advise what could be done to save it. Several methods of water-proofing on the inside of the tank were considered and a contract was awarded to a firm applying surface treatment under a guaranty of 5 years as to the tightness of the work. Considerable saving of money by the use of this interior surface treatment was made over a membrane and very large saving as compared with the cost of a new steel stand-pipe and the tearing down of the old concrete one.

Had a membrane water-proofing method been used an extra charge would have been necessary for the cutting out on the inside of a large amount of concrete at each of the construction joints. The repairs to this tank were completed in 1920 and have given good satisfaction.

With regard to the repairs, a surface treatment plus a plaster coat treatment was applied to the inside surface of the tank. The material used to treat the inside face was also mixed with the cement which was applied to the repairs to the joints which had to be pointed up.

In many cases membrane systems are preferable to all other systems. There are, however, cases in which membrane systems cannot be used and a plaster coat or a surface treatment can be used. For instance, where walls are saturated with water and water is seeping or running down the face of the wall, the speaker knows of no membrane water-proofing company that would undertake such a job and give a guaranty of its tightness. He does know of several

* Mgr., New York Dist., Western Waterproofing Co., New York City.

surface-treatment and plaster-coat treatment companies that not only will undertake the job but will give a guaranty of its tightness and such companies have made good on their guaranty. In conclusion, therefore, the speaker does not believe that it is consistent for the Society to draw up specifications that will eliminate all other methods of water-proofing except the membrane method. It would be the speaker's recommendation that, before reaching a definite conclusion, the Committee should first call on firms that manufacture or apply materials to concrete surfaces for water-proofing and treatment against dampness, to furnish all the data for a thorough investigation. On a final conclusion of the advisability of the several methods being used as water-proofing mediums, the Committee could be authorized to bring in recommendations that certain methods could be used for certain classes of engineering work.

Elwyn E. Seelye,* M. Am. Soc. C. E.—The best standard practice on water-proofing of basements and structures under hydrostatic pressure, consists in a water-proof plaster coating. Integral water-proofing is a more economical means of water-proofing than a plaster coating. Its success must depend on the reinforcement of the structure in such a manner that it will not crack.

The recommendation on oil-proof coating is too indefinite and is of no value unless chemical compounds are mentioned. For concrete exposed to the action of sea water, nothing is said with regard to requiring the metal reinforcement to be galvanized. The speaker believes that this might be a valuable method.

George L. Lucas,† M. Am. Soc. C. E.—This specification does not include all methods of water-proofing with bituminous materials. The particular method the speaker has in mind is brick laid in asphalt mastic used in the construction of the Rapid Transit Subways in New York City. Both the membrane and the brick in asphalt mastic methods are used for water-proofing subways, but for water-proofing structures below ground-water or sea level, brick in mastic only is used. This type of water-proofing has been in service for more than twenty years under the most trying conditions, without sign of failure, and the speaker wishes to emphasize the fact that a method that has been so successful should not be overlooked.

There have been failures from time to time in membrane water-proofing in subway work, not necessarily due to defects inherent to the membrane or the materials used, but from causes difficult to guard against, generally oils or solvents, such as gas-drip percolating through the soil to the membrane. However, the brick in asphalt mastic has successfully withstood failure when applied to subway structures built in yielding ground, soft ground, structures on pile foundations, and in rock bottom.

A. Burton Cohen,* Assoc. M. Am. Soc. C. E.—There is a place for integral water-proofing in concrete construction with reference to tank and cellar construction. The speaker refers to the successful use of an integral method in the repairs to cellar walls and floor of the building at 90 West Street, New

* Cons. Engr., New York City.

† Div. Engr., Transit Comm., New York City.

York City, which are considerably below tide-water. In this case, the integral compound was added to the cement mortar plaster coat. The only function of the compound, so far as the speaker knows, was to cause an accelerated set of the mortar of sufficient rapidity to enable its application where there was a slight seepage in spots from the walls and floor. Where a bad leak occurred, the flow was checked by caulking with wooden wedges. Under any appreciable pressure it is hardlly to be expected that this method of repair would be effective.

There are few large structures that have not been subject to cracks of incipient nature. The statement has been made that integral water-proofing has been used in a roof slab, in which sufficient reinforcement had been placed to prevent cracks. This conflicts with the speaker's experience that incipient cracks are likely to form and do so in any work of magnitude subjected to the range of temperature of the temperate zone. In this lies the weakness of the integral method; expansion and construction joints are necessary in structures of magnitude, in bridge work which covers a wide field of concrete construction. Incipient cracks do develop and large ones are not at all unlikely; no amount of compound will prevent these cracks. The speaker's knowledge covering the function or effect of the compound is that it either lubricates the particles of the aggregate or causes maximum hydration of the cement, both actions tending to increase the density of the concrete and to eliminate permeability. The density of the concrete depends largely on its disposition in the forms. In small structures and for structures not exposed to wide changes of temperature there seems to be a place for the integral method which should also include plaster coatings.

There are weaknesses in membrane water-proofing that should be guarded against. If the lines of termination of the membrane are not properly sealed, or if they are placed at a point where the drainage is concentrated, there is danger of a serious failure.

Designs often are carried out with seemingly great economy in the selection of sections based on actual quantities of material and no consideration is given to problems of drainage and water-proofing until plans are completed. Often, these *prima facie* economies must be abandoned for details that will provide for the effective placing of the water-proofing. The concentration of heavy column loads in building construction on a water-proofing membrane should be avoided, due to the danger of puncturing the membrane.

These considerations in water-proofing, together with the considerations that must be given to the correlated subjects of drainage, expansion, and construction joints, comprise as important an element in concrete construction as the design of the foundations or any other structural element.

LEWIS JEROME JOHNSON,* M. AM. SOC. C. E.—The speaker would like to know how one can be sure that the integral compound when deposited restricts its place of deposition to the interior of these alleged pores. If it does not go entirely to the interior, and it is hard to believe that it will, it must interpose

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itself between substances that might better be in contact. Is this a serious matter and what evidence is there on the point? Possibly the comprehensive tests demonstrate that it is not serious.

F. C. WIGHT,* ESQ.—It seems that the Committee must take into consideration the definition of an integral compound. The speaker would say, in general acceptance, that it would be a fifth ingredient to concrete—added in order to give to it some property that it would not possess normally.

H. W. HOBBS,† M. AM. SOC. C. E.—Membrane water-proofing has a definite value, but it is not a panacea for all cases. Necessity has produced the integral compounds, and cases that would not yield to treatment by the membrane method have been satisfactorily treated by this method.

In the design and construction of sea-coast fortifications water-proofing is an important essential. For quite a number of years, the speaker has been engaged in work of this character, and has had favorable opportunity to observe the action of water-proofings of various types, including membrane, integral, and surface impregnating.

In 1905, the speaker conducted laboratory tests of integral water-proofing compounds and, subsequently, made practical application of a number of such compounds. In the laboratory tests it was shown that with the samples containing integral compound, the absorption of water was reduced about 50% by the addition of a small percentage of the compound. Similar results were obtained with samples tested under a pressure of several atmospheres. These tests seemed to warrant further investigation and integral compounds were used on repair work and in new construction. Ordinary seepage as well as leaks under head were stopped successfully by the application of plaster coats containing a small percentage of compound.

Satisfactory results were obtained from the use of integral compound in the construction of a solid concrete wharf built in 1908 in a very exposed place on the Northeastern coast. One-quarter of the area of the deck was finished with mortar containing an integral compound. The finish of the remainder of the deck differed in no way except that no integral compound was used. After thirteen years the part containing the integral compound shows the original section and is practically as good as ever. The remainder of the deck had to be resurfaced a number of years ago.

The speaker's experience in this and many other cases indicates that integral compounds are effective water-proofing agents. It has been claimed by some that other conditions were responsible for the results obtained. The uniformity of the results where integral compounds were used, and the absence of similar results where they were not, would lead to a different conclusion. However, looking at the matter from the other angle, would it be wise to discard an ingredient which exercises so potent an influence on materials and workmanship that a dense water-proof concrete is obtained when it is present?

It has been stated that an integral compound which effects a reduction in tensile strength should not be used. This is not an essential feature for

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† U. S. Asst. Engr., New York City.

general application. There are problems in water-proofing, which can be solved by a mixture of relatively weak tensile strength, provided there is no progressive deterioration of that strength.

It seems apparent that the state of the art of water-proofing and of making dense concrete is such that it is unwise at this time to include in a standard specification any clause that would definitely fix the design and limit further development.

Charles C. Hurlbut,* M. Am. Soc. C. E.—The speaker has used both integral and membrane water-proofing in practice with success. As others have pointed out, there are conditions under which membrane water-proofing is difficult to apply and much more costly than some other method.

The speaker prefers to use the membrane method, except where the expense or additional space required makes it much less practicable; but where the integral method seems to be especially well adapted to the work, he wishes to use it, unless there are good reasons for condemning it. If it contains such elements of danger that it can never be used with safety, let us by all means know it; but let us also know the facts on which that opinion is based.

As to whether a specification for concrete and reinforced concrete should contain a section on water-proofing, it seems to the speaker that the subject of integral water-proofing cannot be avoided. Since it is an integral part of the concrete, the proper proportions and correct methods of use should be laid down in a specification for concrete unless it should be forbidden.

The case of membrane water-proofing seems to be somewhat different, since its use does not affect the composition of the concrete or the design of the reinforcing. A standard and accepted specification for membrane water-proofing would be valuable, but it is a complicated subject and to be of much practical use, a specification covering it should be as thorough and complete as, for instance, the sections of this specification dealing with materials or reinforcement.

A. T. Malmed,† Esq.—Assuming that nine out of ten integral compounds are of no distinct value, that some have too little merit to warrant consideration, or that others have properties of detrimental nature in them, the fact that it can be proven by installations that there are materials that do bring about valuable improvements, and the fact that there are possibilities of still greater development of such materials by reputable manufacturers, should preclude any action on the part of the American Engineering Profession to make this development impossible by excluding such materials as a whole.

Many contractors can present testimony to the effect that a certain piece of work constructed according to correct and careful supervision would prove partly defective whereas a similar piece of work to which a compound of merit had been added to the concrete, was so greatly improved that no one could induce them to construct future work without the aid of that particular integral compound which experience has shown to be of great value.

* Cons. Engr., New York City.

† A. T. Malmed & Co., Philadelphia, Pa.

No reputable or practical contractor assumes that there is something wrong with Portland cement because other ingredients are added to improve the work, nor can it in the least be proven that the purchase of such materials decrease the sale or use of Portland cement. In fact, the speaker can show many cases and prove that the use of certain integral compounds made it possible for cement to be used where other construction materials were first contemplated.

The Joint Committee can render a distinct service to the general industry by taking one of the two following courses. The first is to request from every manufacturer of integral compounds and other concrete specialties a sworn statement of the composition of their products. These are to be submitted to reputable laboratories, and if any ingredients are discovered that are known to have a detrimental effect on concrete, or if an excess of any particular element is harmful, or if any ingredient is impure, such findings shall be printed in the regular journals of the various Societies represented by the Joint Committee, for the benefit of their members and of the general industry. With such cautions on public record, the merit of any material shall then be left to the discretion of the architect, engineer, or contractor.

The second and more constructive course is to send a communication to every concrete specialty manufacturer in America substantially as follows:

"Due to the fact that considerable confusion exists among architects, engineers, and contractors as to the value of integral compounds added to concrete for various improvements, and also due to the fact that many of such compounds are not only useless, but harmful as well—at the same time recognizing that there are in existence some compounds of value—we are wondering whether the reputable manufacturers of the country would be willing to co-operate with the Joint Committee in helping to clear the situation.

"As most of these compounds consist of various compositions easily obtained in the open market, there exists a simple method to analyze and test such compounds to prove either the value or detriment of such materials when used in concrete. It has been suggested that the Joint Committee bring into existence an impartial and competent staff of laboratory experts to examine, analyze, and test each compound and to report in open meetings the result of such investigations.

"We assume that no reputable manufacturer who believes in the merit of his product, who can prove that his product is manufactured so as to cause no detrimental effect on concrete, who does not charge excessive prices for easily compounded and common products, and who can point to existing structures which have been improved by his product, should fear such an investigation.

"The Joint Committee, after such investigation by the laboratory, would print its findings for the benefit of its members or for any architect, engineer, and contractor. A list of all manufacturers willing to enter this investigation would be issued with brand names of each product mentioned and report as to the composition of same, its known value, its limitation, and, if found so, its detrimental effect on concrete.

"The automatic elimination of harmful products will naturally act to the benefit of those manufacturers of meritorious materials, but the only purpose of the Joint Committee is to protect the general industry from such harmful materials.

"Would you therefore be willing to submit your various building specialties for investigation and would you consider sharing in the expense *pro rata* of such an investigation?"

D. H. Dixon,* Assoc. M. Am. Soc. C. E.—Many competent engineers and contractors feel that they secure desirable results by the use of integral compounds, and it does not seem that a standard specification should close the door against what may be an improvement in the art. The use of plaster coat water-proofing should be allowed.

In oil plants steam is sometimes blown into barrels, etc., to make the oil more fluid. If such steam after picking up acids from certain oils is then brought in contact with the concrete in the ceiling of the room, the disintegration will be rapid.

A good wearing surface can be obtained by the addition of a mixture of dry cement and sand. This method has been specified for some years by several of the leading American industrial companies for buildings erected for their own use. It is not desirable that this economical method be specifically prohibited, as might be inferred by a reading of Sections 93 and 94.

The time for placing wearing surfaces should not be limited to ½ hour after the base course is placed, because in most cases the time can be much more than ½ hour without damage to the work.

The speaker has had little success in securing a satisfactory finish with the sand-blast. This method should not be included unless it has been known to give satisfactory results and, if it is included, the specification should give the conditions under which it can be used with success.

Walter F. Ballinger,† M. Am. Soc. C. E.—The speaker would like to see the Committee adopt specifications for the integral method, for the plaster-coat method, and for the membrane method. All three have been used in his practice, generally with success. In each instance where there was not success, it was due to some error in the workmanship. In one instance where the integral method was adopted, due to faulty workmanship the concrete was porous. An engineer can write a beautiful specification, but a great deal depends on the workmanship.

The speaker notes that no mention is made of acid proofing. In a building designed and supervised by his company about a dozen years ago, the owner recently called attention to some disintegration that had taken place inside. It was found that the concrete, in places at the bottom of beams and girders, was loosening, and some had fallen off, and that the steel was rusting. There was acid proofing on the top of the floor, but there was none on the under side. The acid fumes were so active that the water piping in the room had to be removed every two or three years. There were cracks running along the bottom of the beams, parallel to and under the rods. On the steel bars there was a film of rust which caused expansion and pushed out the concrete. Information toward preventing a repetition of that will be helpful.

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† Pres., The Ballinger Co., Philadelphia, Pa.

G. Harrisson,* Assoc. M. Am. Soc. C. E.—Conditions are met where dampness or wet walls practically prohibit the use of membrane water-proofing and where the covering with some rich plaster coat or other form of coating has proven not only cheaper than membrane, but satisfactory, and practically the only solution of the problem.

An experience in the construction of a reservoir may be of interest. Integral compound was ordered for the work, but the man at the mixer became generous with the proportioning, with the result that the supply was exhausted when the work was about half poured. It was considered advisable to continue without using the compound rather than interrupt the work. Extra care was used in placing the remaining concrete, and the final results showed it as satisfactory as where the compound was added to the mixture. Both pieces of work were subjected to the same pressure conditions. The cost of additional compound was saved.

Herbert W. Goddard,† Esq.—Under "Water-proofing", it is specified that "integral compounds shall not be used"; and in the next paragraph it is stated, "membrane water-proofing shall be used".

The speaker has made many tests on concrete of various densities and various mixtures, both with compounds and without them, and feels that there are certain instances where an integral compound can be used to advantage.

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DEPOSITING CONCRETE. FORMS. DETAILS OF CONSTRUCTION.

By Messrs. C. T. Morris, D. H. Dixon, Herbert W. Goddard, L. E. Kern, A. N. Talbot, Edward Godfrey, F. W. Scheidenhelm, W. H. Rose, A. Burton Cohen, Henry Manley, Jr., Manton E. Hibbs, F. R. McMillan. N. M. Loney, S. C. Hollister, and H. C. Berry.

C. T. Morris,* M. Am. Soc. C. E.—The speaker has written into the specifications for the Stadium of the Ohio State University, that spouting directly into the forms will not be permitted, and he does not believe that concrete of any consistency can be run through a spout and not separate to some extent. The concrete used in the Stadium is as dry as it can be made and still be worked around the reinforcing, and yet with concrete of that consistency, after it is run through a 45-ft. spout the gravel will be separated from the mortar to some extent. For that reason, the contractors are compelled to spout it into boxes or hoppers, and then deposit it in the forms.

A slope of about 2½ to 1 is as flat as can be used with the consistency of the concrete being placed.

In Section 77, it is stated that the joint should be given a heavy coating of neat cement. It is not clear whether dry cement or grout is meant. The speaker has had experience with both, and finds that a heavy coating of neat cement grout gives better results than dry cement. The specification should be made clear on this point.

The speaker thinks that it would be well if the specification for the grout in the bonding in Section 43 was the same as in the other Sections with regard to a water-tight joint. There should be grout on the surface before any concrete is deposited on the hardened surface. In regard to the last paragraph, Section 58, about re-shoring, the speaker does not think that in the re-shoring of a beam the same pressures can be obtained that were originally on the forms. He never allows the forms to be disturbed under a beam until the concrete has sufficiently hardened so that the beam will carry its load without re-shoring.

It might be of interest to know the type of expansion joint that is being used on the Ohio Stadium. In 1921, the speaker visited all the large stadia in the United States, and all the large ball park grand-stands, and other structures of that nature, in order to study particularly the question of expansion joints. Although it may not be necessary in a 200-ft. building to use expansion joints, few structures, anywhere, were seen over 200 ft. in length that did not have cracks in them due to contraction; and it was due to this investigation, that determined the use of an expansion joint every 60 ft. The structure is divided into units 60 ft. long, and those units are entirely separated. The columns are twin columns at the expansion joints. The expansion joint is filled with a pre-moulded joint filler, and under that is a U-shaped lead joint which is cast into the concrete on both sides of the joint, to make it water-tight, the asphalt being merely a filler.

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The expense may not be warranted, but it was felt that the building of the structure without adequate provision for expansion was not justified, because it was expected to utilize the space under the benches for dressing-rooms, hand-ball courts, and winter quarters for the track teams.

D. H. DIXON,* Assoc. M. Am. Soc. C. E.—The general recommendation in Section 37, that spouts have a slope of one vertical to two horizontal should be qualified. The speaker believes that gravel concrete of a consistency as dry as is safe to use in reinforced concrete buildings, can be placed with chutes, as now built, having a slope of one vertical to three horizontal.

Section 40.—This Section should be changed to provide that the concrete shall be kept thoroughly wetted, when practicable. It would be difficult to keep wet, certain parts of the concrete in a building. As yet, no experiments on the strength of concrete cut from buildings have been had to show that the concrete in the columns, etc., does not gain strength in a satisfactory manner, under the conditions that exist in a building during construction. Nothing should be done in this specification to increase the cost of a building without first having proof that the increased cost is made necessary by an actual requirement to obtain good work.

Section 41.—Concrete to which a small percentage of calcium chloride is added shows a considerable gain in strength, even if it is frozen immediately after being mixed. Similar concrete, without calcium chloride, if frozen immediately after mixing, will, when thawed out, return to the mushy condition it had when first mixed.

Calcium chloride would be of considerable value when reinforced concrete work is carried on under winter conditions, if it was not for the fact that the Bureau of Standards in some preliminary experiments has found indications of a tendency for the steel reinforcement to rust. There is also the possibility that the presence of the calcium chloride may lead to injury through electrolytic action. The advantages to be gained by the use of calcium chloride are sufficient so that it is to be hoped that some competent laboratory will undertake a thorough investigation of the results of its use. While waiting for further information on the action of calcium chloride in reinforced concrete, there would not seem to be any good reason for prohibiting its use in concrete that does not contain reinforcing rods.

Section 54.—There should be no objection to the use of wire ties, provided the wire is kept back or cut back 1 in. from the exterior face of the concrete, to prevent corrosion. In some work, the use of wire instead of bolts is advantageous.

Section 67.—As quartz has materially greater expansion, under heat than limestone or trap, Section 67, as now written, will require that, when quartz gravel concrete is used, the amount of fire-proofing must be increased 1 in., and, also, metal mesh, not exceeding 3 in. in greatest dimension, will have to be placed 1 in. from finished surfaces.

This provision will have a marked effect on the cost of construction in New York City, Buffalo, N. Y., and other large cities where quartz gravel is the most economical source of supply.

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The fire tests of the columns at Pittsburgh, Pa., showed that quartz concrete gave the poorest results when it was used in columns containing spiral reinforcement. In such spirally reinforced columns, the quartz started to peel off in about ½ hour, whereas quartz concrete columns that had no spiral reinforcement, stood the heat much better. In the spiral columns, the spiral reinforcement seemed to create a plane of weakness so that when the quartz concrete became hot, it peeled off to the face of the spiral.

This section, as written, would require, in a building where quartz gravel was used, that all fire-proofing be made 1 in. thicker, with also the addition of the wire mesh. This would not only be required for the spiral column, but also for the walls and ceilings.

The quartz concrete spiral columns will be much more seriously affected by fire than other parts of the structure. Therefore, it does not seem necessary to specify the same treatment for fire walls which contain little reinforcement and are large flat surfaces that will be much less damaged by fire than the spiral column with its network of reinforcement making a plane of weakness.

The desirability of penalizing the use of quartz gravel concrete must also be considered from an economic standpoint. If Section 67 remains as written, every reinforced concrete building in New York City, Buffalo, and many other places, will be increased in cost and the increase in the cost must be balanced against the greater fire loss that may result if quartz concrete is used in the comparatively few buildings that are subjected to serious fires.

It is also necessary to keep in mind that those who build will use what they think is the cheapest construction suitable for the purpose and, therefore, if the use of concrete is made too expensive, many will turn to the use of timber or some form of semi-fire-proof construction. It may be, therefore, that the practical prohibition of quartz gravel concrete will lead to an increase in the use of less desirable forms of construction.

Before penalizing quartz concrete so severely, a most careful study should be made of the results obtained with it for columns and for flat surfaces, as compared with other forms of fire-proofing that are now in use.

Section 70.—In Chapter II where the term, "Capital", is defined, it is stated that the capital is built monolithic with both the floor and the column. It should not be necessary to concrete the column and the floor on the same day.

Section 74.—The speaker has not obtained good results with petrolatum in preventing new concrete from bonding to old concrete. Cold-water paint or cheap oil paint will cause an absolute separation.

Section 75.—A properly constructed expansion joint is both expensive and undesirable from an operating standpoint. The speaker believes that buildings 300 ft. long, or longer, can be built without expansion joints and without danger of injury, unless the section of the building, at some point near its middle, is much reduced by openings. The spacing of expansion joints depends so much on the details of design that it seems undesirable to place an arbitrary limit in a standard specification.

Section 77.—Unless required because of some assumption made in design, the speaker prefers to let the crack occur on the straight line of the joint in

the floor and then close the crack with minwax or other semi-elastic filler. Attempts to bond the two surfaces will sometimes lead to the formation of an irregular crack.

Herbert W. Goddard,* Esq.—The desirability of further consideration of Section 77 has been suggested, and in furtherance of this suggestion the speaker wishes to state that in a number of cases which have come to his notice, this type of joint did not prove entirely satisfactory.

In one case, where a joint had been made similar to that indicated in Section 77, it was considered advisable to reconstruct it, which was done as follows: The surface of the first section of concrete was provided with continuous V-keyways. Asphalt fabric was applied to the surface of the concrete first placed; a rope of spun oakum was placed in the apex of the V-keyway and the next section of concrete was placed. The spun oakum in expanding caulked this joint, making it water-tight. This type of joint, both with and without the asphalt fabric, has been used on projects under the speaker's direction since then, with satisfactory results.

L. E. Kern,† Esq.—The architect is a user of concrete. He, therefore, is naturally interested in matters pertaining to its standardization, and presumably will be supposed to use the standard specifications being prepared by the Committee. The speaker's criticisms and suggestions, will relate to points that have been the cause of trouble in the every-day work of the architect. They relate mainly to wording and to subjects on which more specific requirements would be desirable.

Architects are trying to eliminate the expressions "as approved by the architect" and "or other approved method". In fact, the tendency is toward the elimination of the word, "approved". It has been and is the cause of much trouble and misunderstanding. It is misleading, and the bidder is justified in calculating on any material or method that he has reasonable grounds for assuming would be approved.

The expressions, "approved by the engineer" and "other approved method", are of frequent occurrence in the Tentative Specifications. Their elimination, wherever possible, would materially improve the usefulness and value of the finished document.

There are other clauses that appear to be indefinite in a somewhat different way. For example, in Section 40, it is stated that "exposed surfaces of concrete subjected to premature drying shall be kept thoroughly wetted for a period of at least 7 days." The question might naturally arise as to whether or not some particular exposed surface was subjected to premature drying. To an experienced concrete engineer, the clause as written may appear to be sufficiently definite. It would be unwise, however, to assume that the average architect using the specification or the average contractor calculating on the work, was a trained concrete engineer. Many of the larger offices have trained engineers in their organizations, but it is probable that 90% of the architects' offices do not. If it is not practical to make all such clauses more

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specific, a foot-note descriptive of recognized good practice would be of material aid to the average architect in interpreting the requirement.

There are other clauses in the Tentative Specifications that are definite, but that, in their present form, and without explanatory notes, would be regarded with suspicion. Some of them are at variance with common practices; for example, the requirement that "salt, chemicals, and other foreign materials shall not be used to prevent freezing". There are a number of manufacturers who advocate the use of their products to prevent freezing. Some of their claims appear to be plausible, at least, to one who is not an expert on the subject.

The architect needs the data that the Committee presumably had, in order to refute the claims. The inclusion in the finished specification of results of tests and investigations, supporting the stand taken by the Committee on changes in present common practice, will materially aid in bringing about a general adoption and use of the standard.

Section 52 states, "lumber used in forms * * * shall be free from loose knots or other defects." What are other defects? All lumber has some defects. On what commercial grade of lumber would a bidder estimate?

Section 53 states, "sufficiently tight to prevent leakage of mortar". Is it commercially practical to enforce this requirement rigidly?

Section 54 states, "Wire ties will be permitted only on light and unimportant work." A little light on what is light work would be illuminating.

Section 54 states, "special care shall be used to prevent bulging". Is it not meant, that forms shall not bulge? As long as they do not bulge does one care whether or not special care was used? In spite of special care, the forms might bulge.

Section 56 states, "the inside of forms shall be coated with non-staining mineral oil, or other approved material". Most architects would have to insist on mineral oil or approve something they did not know anything about. What are some of the other materials that he should approve?

Section 58 states, "Forms shall not be disturbed until the concrete has adequately hardened, etc. * * *". A foot-note states "many conditions affect the hardening of concrete and the proper time for the removal of the forms should be determined by a competent and responsible person". This is undoubtedly true, but suppose the contractor's competent and responsible person and the architect's competent and responsible person do not agree. Competent and responsible persons are not always available for small work. More specific information either in the specification proper, or in the footnote, would serve a most useful purpose.

These few points are illustrative of some of the ways in which the architects may be able to co-operate with engineers. They are users of concrete and are responsible to their clients for the design of the concrete work in their buildings. They are, therefore, interested in the specifications and if the Structural Service Committee of the American Institute of Architects, can be of any assistance, it is hoped that the Committee will enlist its active co-operation.

A. N. Talbot,* Past-President, Am. Soc. C. E.—In connection with the matter of the depositing of concrete in freezing weather, where the mass is large, the speaker would like to suggest, for the consideration of the Committee, that it try to devise some such statement as this, that the concrete to be deposited shall have a temperature such that the concrete in place will not reach the freezing temperature at the surface, or whatever may be best, within a definite time, such as 48 hours, such a time as will provide for the concrete to set thoroughly. It is known that if after the concrete has set, it freezes and remains frozen, hardening will go on even at the colder temperature, although at a slow rate and the concrete will not be injured. The protection from lowering of temperature given by the forms, or any other protection that may be provided, should be taken into consideration in determining when freezing will occur. It seems necessary to require that the atmospheric temperature shall be 40° or 50° Fahr., or some other temperature. The result can be told by a thermometer. It can also readily be forecast by the use of diagrams and tables which have been prepared,† based on the properties of fresh concrete, so that by reference to a table or diagram and a little calculation, one can tell what the temperature of a given mass of concrete would have to be in order not to reach a given temperature within 12, or 24, or 48 hours, if the air reaches a specified temperature.

Edward Godfrey,‡ M. Am. Soc. C. E.—The speaker thinks the subjects, chuting of concrete, and the consistency of concrete, should not be separated, although they are in different parts of the specifications, as one cannot consider one without considering the other. The specifications require a 2-in. slump in mass concrete. This is a stiff concrete which cannot be deposited through chutes in the ordinary way. The speaker has seen concrete deposited by a chute with an inclination of 3 or 4 to 1. This was "juicy" concrete; it makes a dense, cheap concrete, so that it is practicable to place it quickly and economically. Stiff concrete may have more compressive strength, but compressive strength is not very essential in mass concrete.

F. W. Scheidenhelm,§ M. Am. Soc. C. E.—At one time, the speaker took for granted that chuting was a perfectly acceptable method of placing concrete. At present, he is frankly doubtful of the advisability of applying that method in certain cases.

As far as his own work is concerned, he would not hesitate to continue the use of spouting or chuting where the concrete is to be made rich, that is, with a relatively high proportion of cement to aggregate, and where the larger aggregate is relatively small. Therefore, he has no doubt that it is entirely proper to use chuting in ordinary building construction. His doubt is confined rather to those cases where the aggregate is large in size and where the concrete is relatively lean in cement—to cases where the quantity of concrete, and, therefore, the expense of the work, is so great that it is not economically feasible to use cement in the proportions that are used in building

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† *Bulletin 123*, Univ. of Illinois Engineering Experiment Station, Studies, etc.

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construction. Cases of disintegration of concrete are known where consideration of the evidence does not clearly eliminate the method of chuting as being at least a contributory cause.

Section 37 contains a specification to govern spouting or chuting. In the second last sentence, there appears the provision that "the delivery from the spout shall be as close as possible to the point of deposit." This concerns one of the doubtful features in the method, involving, as it does, the matter of segregation—the separation of large aggregate from mortar and even of fine aggregate from the cement.

Section 58 states: "Forms shall not be disturbed until the concrete has adequately hardened, nor shall the permanent shores be removed until the structure has attained its full design strength." The speaker is doubtful as to whether it is essential that shores be retained until that degree of strength has been attained. Is there not some doubt as to the time when the concrete has attained its full design strength? This specification would seem to require further definition or clarification. If one predicates the determination as to that time on the result of test specimens, one certainly does not obtain the same result that would be obtained by a direct test of the beam or slab in point. Moreover, from the foot-note* there is indication that there is some doubt about this matter. It is there stated that decision should be made by "a competent and responsible" person. In general, the speaker believes that, as between the contractor and the engineer, where the job can support an engineer competent to assume responsibility, the engineer should take the responsibility. Thus, in the present instance, it seems that the engineer should accept the responsibility, at least to the extent of setting the minimum time limit in days for the removal of shores. There are other cases throughout the specifications where the Committee might well consider whether responsibility should not be placed on the engineer in charge.

W. H. Rose,† Assoc. M. Am. Soc. C. E.—With regard to Section 75, in which it is stated that "structures exceeding 200 ft. in length * * * shall be divided by means of expansion joints," it is believed that it will be found that the great majority of reinforced concrete buildings up to 300 ft. in length have no expansion joints. An expansion joint is troublesome and expensive, and if the Committee would make a careful canvass of buildings, say, about 300 ft. in length, it is believed that practically no cases would be found where expansion joints were used and that there would be few if any cases that showed evidence of serious deterioration due to temperature expansion and contraction. The amount of steel in modern industrial buildings, where the floor loadings are usually heavier than in buildings intended for other purposes, seems to be entirely adequate to care for temperature stresses within the usual range of temperature. The buildings are heated, and the range of temperature is not as great as in the case of a retaining wall. It is thought that a maximum length of 60 ft. between expansion joints, in the case of retaining walls, is a sound requirement. In view of the expense and trouble

* *Proceedings,* Am. Soc. C. E., August, 1921, p. 79.

† Dist. Mgr., Lockwood, Greene & Co., New York City.

involved in providing expansion joints in buildings, the speaker thinks the matter should receive careful consideration before a maximum length between expansion joints is prescribed.

A. Burton Cohen,* Assoc. M. Am. Soc. C. E.—It could be said that the specifications do not go far enough in recommending preference to bolts and rods over wire ties in form construction. Improved workmanship would result with the discontinuance of the practice of using wire ties twisted in place by hand. The result is poor form alignment and a finished wavy surface of the concrete.

The speaker is of the opinion that spouting should be controlled by a clause in the specifications requiring delivery of concrete by spout to an auxiliary hopper or platform from which it is to be distributed uniformly to all parts of the forms. Where the form covers a wide area, the tendency is to discharge the concrete from a single point and depend on the concrete to flow to all parts of the form, which results in a wet mixture and the separation of fine and coarse aggregate. With the present practice of recommending a comparatively dry mix, vast improvements in the flexibility of moving the discharge from the spout are necessary before it would be safe to disregard precaution in the suggestion of a auxiliary hopper or platform.

Henry Manley,† Jr., Assoc. M. Am. Soc. C. E.—Section 41 is an excellent specification for the protection of concrete against freezing in building construction, but rather broad for general application to all classes of concrete work. There are two points that the specification seems to fail to consider, and that, in the speaker's opinion, might be amplified. The first is that, by inference at least, the specification assumes that concrete of any class may be poured in any location during freezing weather. The second is that the specification assumes the same method of protection for thin sections as for mass concrete. Would it not clarify the specification to recognize at the outset that three general conditions exist: (1) conditions which forbid the placing of concrete in freezing weather; (2) conditions where protection by means of insulation are adequate; and (3) conditions where both protection and artificial heat are necessary?

In all cases, the concrete should be heated before being placed. The use of hot water for this purpose has been suggested, and, in this, the speaker concurs, particularly with mass concrete. Under proper conditions, hot water seems to accelerate the setting of the cement to an extent that the heat, generated in the setting action, is brought into play before the initial heat of the concrete has radiated. This seems to be an accelerated set, rather than a flash set, and so far as the speaker's experience goes, has not affected the strength of the concrete. The heating of the aggregates alone does not seem to produce so marked an effect.

During the construction of that part of the New York Rapid Transit System, known as the Queens Boulevard Concrete Viaduct, the speaker made some crude investigations of this phenomenon. Concrete with an average

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† With Lockwood, Greene & Co., New York City.

thickness of 3 ft., was being placed in the arches in units of approximately 200 yd. There was no protection by artificial heat, but the concrete was covered with canvas and straw. Concrete at a temperature of 45° Fahr., was placed in the afternoon. The air temperatures varied from 36° to 40°, falling well below freezing during the night. Self-registering maximum and minimum thermometers were placed in metal tubes which passed through the center of the mass. The following morning the thermometers were removed and read.

Five or six of these experiments were carried out and, in all instances, a marked temperature rise took place. In no case, was a temperature recorded below that at which the concrete was placed, which indicates that the rise was steady. The maximum temperature recorded was 98°, and the average rise was about 30°; in all cases, the rise occurred within 16 to 18 hours after the concrete had been placed.

It is recognized that the foregoing is no proof that surface freezing will not take place, indeed, such a possibility was kept constantly in mind on the work referred to, but it is most probable that if such freezing did take place, it would be quite shallow and would not affect the strength of the mass as a whole.

The speaker's criticism of the specification is not of what it contains, but of what has been omitted. There are certain conditions under which concrete should not be placed in freezing weather. The proposed highway specifications forbid placing concrete below a certain temperature. Is it not advisable to recognize fairly the widely differing conditions between adequate protection of thin section concrete and of mass concrete, and cannot this be accomplished without greatly amplifying the specification or departing from the broad scope which it is intended to cover?

Manton E. Hibbs,* Esq.—There are a number of things connected with Philadelphia buildings that are of interest, pertaining to the wear and tear of building material, and one of these bears on the protection of steel in concrete, especially in those parts exposed to the weather. A building in Philadelphia which was designed by an engineering firm of National reputation is practically going to pieces on the outside.

This condition has reached such a stage that the owners are seeking for a method to remedy this disintegration, and to protect, especially, the outside face of the columns. The building is a large one and was erected almost continuously, in relays of 8 hours. The outside columns are of rectangular shape, and contain two spirals, with a theoretical protection of 2 in. on all sides, which protection is in accord with the Philadelphia law. A number of these columns are spalling, because the rings of the spiral have been pushed to the outside surface so that, in many cases, only ½ in. of protection is left. These spirals were supposed to have been held securely in place.

This specification requires that walls and slabs be protected with only 1 in. and less for outdoor structures. Theoretically, 1 in. may be sufficient, but when concrete is poured, a hydraulic surge is created toward the outside face of

* Civ. Engr., Philadelphia, Pa.

the forms, and the steel is likely to be displaced about ¼ in. There should be a difference in the degree of protection between the outside faces of columns and spandrel beams exposed to frost, rain, and sun, and the inside faces which are occasionally exposed to fire. It would be better to sacrifice some of the inside protection and make the outside fire-proofing of greater depth, as a good measure, both for safety as well as for the future life of the building.

F. R. McMillan,* M. Am. Soc. C. E.—A building, 1 200 ft. long, would tend to shorten about 6 in. during the normal hardening of the concrete.

A number of things resist this shortening, such as the embedded steel which acts as the longitudinal steel in a column, and the anchorage of the building to the ground which effectively restrains the lower portion. However, in a building 1 200 ft. long, such shortening might result in cracks that would be of considerable damage. In a certain instance that has come to the speaker's attention, measurements were made in a building about 200 ft. long which, at the top, showed a shortening of 1½ in. and, at the ground level, no movement at all. It is the contraction that causes most of the cracking observed in buildings, and it is these cracks that the joints are designed to eliminate.

The speaker prefers to use the term, "contraction joints", as it is an aid when considering the proper number and arrangement for a particular case. He is inclined to agree that in a great many cases cracks may be less objectionable than the joints, but if a designer desires to eliminate all cracks he must provide joints closer than is called for by the specifications, and he must carefully arrange their position relative to the other features of the design.

The question of whether 200 or 300 ft. should be adopted in the specification seems to be largely a matter of opinion. The Committee was not entirely in accord on the 200 ft.

N. M. Loney,† M. Am. Soc. C. E.—This specification requires for chutes an angle of approximately 2 to 1, whereas on hundreds of buildings now in use, concrete was placed with chutes at an angle of 3 to 1. The standard by which the art is judged, is capable of much improvement, but, nevertheless, practicable, workable buildings are being produced.

With regard to the prohibition of the use of salt or chemicals as an anti-freezing mixture, with suitable provision as to their use, there are a number of cases in which considerable money can be saved, and equally good buildings produced. In the case of this Section, a number of restricting clauses, which, if properly applied, will allow the use of approved materials, and will not prohibit all the development that may occur in this line.

Not long ago a decision had to be made as to whether to omit expansion joints in a building 1 200 ft. long. It caused a great deal of worry as to whether the architect's instructions to do so should be accepted without protest. On investigation, a case was found where two 1 400-ft. buildings of the same materials, had been constructed side by side, one of which was provided with expansion joints. Both buildings cracked, and the one that had expansion joints did not crack at those joints. Apparently, they were both well built.

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† Vice-Pres., Thompson, Starrett Co., New York City.

Another building of similar length, now two years old, has not shown a single crack. The owner preferred to take a chance on what was more of a disfigurement of the building than an actual weakening of the strength, rather than to truck over the openings that necessarily occur at expansion joints. This is contributed as a matter of experience that has come within personal observation. The speaker believes, however, it would be desirable for the Committee to recommend the maximum length between expansion joints, which length should be not over 300 ft.

S. C. Hollister,* Assoc. M. Am. Soc. C. E.—There is probably no general detail of construction that received so much consideration at the hands of the Committee as the question of expansion joints. Buildings with sections up to 1 400 ft. exist without expansion joints and without serious distress, to all appearance. Other buildings and other structures, as, for instance, retaining walls on satisfactory foundations, where they are subject to considerable change of temperature, have cracked in lengths of 40 ft.

A canvass was made of building practice and building experience and the consensus of opinion from that canvass seemed to be that 200 ft. was the average length of building that would give satisfaction from the standpoint of spacing of expansion joints.

H. C. Berry,† M. Am. Soc. C. E.—Construction men have shown a desire to be relieved from the requirement that forms be left in place an arbitrary period. They know that under favorable weather conditions forms may be removed much sooner after pouring than when the weather is cold. They can tell by the "ring" of the beams when struck with a hammer that the concrete has hardened normally. Some will take the responsibility of early removal.

Is it not practical to make a study of conditions and of data on hand, as well as to make some tests, with a view to changing this requirement so the time of removal of the forms will depend upon aggregate temperature (the area of a time-temperature curve after pouring), a similar quantity based on humidity, on consistency of the concrete, and the minimum temperature since pouring? This information is available in the reports of the U. S. Weather Bureau.

It is offered as a suggestion that a simple practical specification, involving the constants of the concrete itself and the data from the weather report, may be written that will remove the responsibility from the construction superintendent who wishes to take advantage of favorable weather and will also serve as a check on his removal of forms too early in cases of unfavorable conditions.

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DESIGN.

By Messrs. N. M. Loney, F. R. McMillan, D. H. Dixon, R. L. Bertin, Edward Godfrey, R. C. R. Gautier, W. A. Slater, A. N. Talbot, and Elwyn E. Seelye.

N. M. Loney,* M. Am. Soc. C. E.—A number of engineers in New York City, who are constructing reinforced concrete work, were interested in the practical application of the Tentative Specifications. A committee of five engineers was selected, who are ordinarily engaged in the commercial designing of concrete structures. They were instructed to estimate the cost of a typical building under different conditions of loads and stresses and concrete strengths under the proposed new specifications and the New York Code. This hypothetical building is calculated for both flat slab and beam and girder construction, using live loads 75, 150, 300, and 600 lb. per sq. ft. The building was 80 by 300 ft., six stories in height, no basement, the first floor being on the ground; the roof load was 40 lb. per sq. ft., live load, and the weight of the roof and cinders was 30 lb. per sq. ft. Arbitrarily fixed material prices were used and, in most cases, two independent checks were obtained on each result for the flat slab building. The summary of the results is as shown in Table 5.

TABLE 5.

Type of building.	Live load, in pounds per square foot.	Cost of Steel and Concrete, New York Code:		Percentage of Cost, by Tentative Specifications, Based on Cost of New York Code = 100%. Design strength of concrete, in pounds.		
		Cost.	Percentage.	2 500	2 000	1 500
Flat slab design	75	$66 718	100	116.	109	104.5
		68 620	103	115.5	109	107
	150	75 928	100	.....	111	111
		78 065	103	113.5	109	110.5
		78 690	104	112.5	109.5	107.5
	300	101 205	100	113.	108	111
	600	146 223	100	113.6	109	111
Beam and girder design	75	$66 067	100	110.	104	102
		67 255	102	101	102	105.5
	150	77 665	100	105	101	100
		78 130	100.5	....	108	....
		81 030	104.	103	103.2	107.5
	300	100 700	100	104	100	101
	600	156 701	100	98.7	99.4	103.8

It appears that in New York City a flat slab building would cost about 11% more if built under the proposed specifications instead of the Standard Code.

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In beam and girder construction the difference would not be so great as is shown.

In considering this matter, it must be remembered that such buildings are usually taken in competition and only a limited time is allowed for calculations. In order to be conservative one would necessarily take the strength allowed by the tables and the slump, which is known to be good practice. Therefore, it is believed that the tabulation presents a close approximation to what the cost would be under this specification.

To obtain the 2 000-lb. strength of concrete, the cost of the cement, under the New York Code is calculated at $3.35; for the 1 500-lb. concrete, under the proposed code, the cost of cement was calculated as follows: 1 500-lb., $3.50; 2 000-lb., $4.38; and 2 599-lb., $5.50.

F. R. McMillan,* M. Am. Soc. C. E.—The recommendations which the Joint Committee has prepared, covering the design of reinforced concrete columns, are, perhaps, quite a departure from current methods of designing columns and, therefore, the discussion should properly be prefaced with a brief outline of the important features that led to those conclusions.

The Committee endeavored to consider all the test data bearing on the question of columns and to attempt a logical analysis of the stresses in a column under working loads. All previous formulas are based on consideration of the ultimate load, the factors for the various elements—core area, vertical steel, and the spiral reinforcement—being based on the carrying capacities as found from ultimate load tests.

There is nothing in all the published data available to indicate that, under working conditions, the spirals actually add to the carrying capacity of columns. The acceptance of this fact is one of the three principal features in which the proposed specification departs from current practice: First, the provisions ignore the spiral as a direct carrying element under working conditions; second, that it makes allowance for the initial compression in the longitudinal reinforcement due to the shrinkage of the concrete during the period of setting; and, third, the recognition of the continued deformation which takes place in concrete under load. This property of concrete which has been referred to by some as plasticity, but which the speaker prefers to call yield, is very important when the combination of the longitudinal steel and the concrete is considered.

The Committee examined carefully all the test data available and arrived at a formula which, in effect, takes into account both the initial shrinkage stress in the longitudinal reinforcement and the further increase due to the yield factor, although on its face the formula does not indicate that this is the case.

The studies leading to these provisions were carried out by the speaker and presented in a paper before the American Concrete Institute in February, 1921. The formula arrived at in that paper shows the safe working load on a column to be a function of the ratio of longitudinal steel and the permissible stress limit. For the recommendation of the Committee a limiting stress of 25 000 lb. per

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sq. in. was adopted and a formula derived which gave approximately the same working load, but which is in the form of the previous Joint Committee formula. This was accomplished by varying the allowable concrete stress with the longitudinal steel ratio.

It will be seen from a little study that the greater the steel ratio, the less the initial shrinkage stress and, therefore, the greater the margin between initial stress and the limit fixed for safe design. Because of this, it is possible to achieve the desired result with the old formula by allowing a higher unit stress on the concrete for higher longitudinal steel ratios, as is done in the proposed formula. The agreement between the proposed formula and that derived in the paper referred to, is not exact, but it is entirely within the limits of accuracy warranted by the data available.

Following out logically the theory on which the column formula is based, no higher value would be permitted on the spiral column than on the rodded column. However, all the test data show greater security and higher ultimate loads with increasing amounts of properly arranged spirals. As the proposed formula allows increased load in proportion to the vertical reinforcement, it seemed best to provide an increasing factor against ultimate collapse by increasing the spiral proportionately. It might be claimed that for the small percentage of verticals permitted in the rodded column, and, therefore, small loads, only a small amount of laterals are needed to guard against the possibility of ultimate collapse. The provisions of the Committee covering rodded columns are a compromise between the two positions. They are more liberal to the rodded column at the low percentages of verticals permitted than to the spiral column for the same percentages. This concession was made to the practice of the past and is admittedly illogical in the light of the treatment of the spiral column.

D. H. DIXON,* ASSOC. M. AM. SOC. C. E.—The working stresses to be used in design are established as given percentages of the strength of cylinders made from the concrete and tested at an age of 28 days immediately after they are removed from damp sand storage.

It seems to be a well established fact that if a test cylinder is removed from the damp sand at the end of 25 days and allowed to dry at ordinary room temperature for 3 days before testing, the strength of the cylinder is increased about 30% over the strength of a similar cylinder which is left in the damp sand for the entire 28-day period.

The largest commercial testing laboratory in the United States has always dried the test cylinders before placing them in the machine. The tests reported by the New York Subway authorities are on cylinders dried two days before testing. For years, engineers have formed their judgment as to the strength of the concrete they were using, from tests on samples which were dried before the load was applied.

The requirement that the strength of concrete is to be determined by tests on wet cylinders, would mean that a 1 : 2 : 4 concrete, made from good aggre-

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gate, would be considered as having a strength of only about 1 500 lb. per sq. in., instead of about 2 000 lb.

For the past twenty years, it has been the custom to consider a 1 : 2 : 4 concrete of satisfactory aggregate, as having a strength of 2 000 lb. per sq. in., at 28 days. The speaker knows of no case in building construction where this assumption has not been justified by satisfactory results.

In the design of the floors of a building, it is also a fact that for the dead load as high a factor of safety is used as for the live load. The dead load cannot be materially increased and, therefore, the factor of safety against any overloading in the floor as built is much greater than would be inferred from the relation of the unit stresses to the ultimate strength of the concrete or the elastic limit of the steel.

The speaker feels that there is no justification in requiring that more cement be used than has been required in the past to obtain a strength of 2 000 lb. An examination of the reinforced concrete buildings erected during the past twenty years, will sustain this position and justify the expectation that a revised specification should materially reduce the cost of beam and girder construction and certainly should not increase the cost of flat slab construction. A comparison of estimates will show that under this proposed specification the cost of the skeleton of a flat slab building will be increased about 11% and instead of the cost of the skeleton of a beam and girder building being reduced, the cost will be increased about 2 or 3 per cent.

One of the principal reasons for this increase in cost is the fact that concrete that has been considered as 2 000-lb. concrete for the past twenty years, with entire success, now is, under this proposed specification, made 1 500-lb. concrete. To prevent the placing of this burden on the building industry, it will be necessary to revise this proposed specification to provide a measure for the strength of concrete that will agree with the standards now in satisfactory use, or it will be necessary to recognize that a new measure for the strength of concrete has been adopted, which will require a proper increase of the percentages used to obtain the allowable working stresses in Sections 197, etc.

R. L. Bertin,* M. Am. Soc. C. E.—The purpose of this discussion is to show the influence that the Joint Committee report would have on the cost of spirally reinforced concrete columns, as compared with the cost of columns designed in accordance with the New York City Building Code.

Table 6 gives the assumed cost of the materials and labor. In Table 7 are given: (1) the cement, sand, and stone factors used in arriving at the cost per cubic yard of the different classes of concrete, namely, 1 : 2 : 4 and 1 : 1½ : 3 concrete, which are the mixes specified in the New York City Code and 1 500-lb., 2 000-lb., and 2 500-lb., concrete mixed in the proportions given in Table 4, of the Joint Committee report; and (2) the total cost of the various concretes per cubic yard and cubic foot.

In Table 8 are given the following: (1) the various combinations of vertical steel and spiral reinforcement used for the New York Code columns; (2) the total compressive resistance of the cores per square inch for every type of

* Chf. Engr., White Constr. Co., Inc., New York City.

column; and (3) the cost of concrete cores per linear foot for a 10 000-lb. load, including the costs of concrete within the core, vertical steel, and spiral steel.

TABLE 6.—COST DATA.

Item.	Cost.	Unit.	Remarks.
Cement	$2.50	Barrel	Material
Sand	1.75	Cubic yard	"
Stone	2.75	"	"
Labor	3.50	"	Labor
Vertical steel	0.04	Pound	Material and labor
Spiral steel	0.055	"	"

TABLE 7.—COST OF CONCRETE MIX.

		Concrete mix.	Labor.	Cement.	Cost.	Sand.	Cost.	Stone.	Cost.	Total cost.	Cost per cubic foot.
NEW YORK CODE		1:2:4	$3.50	$1.34	$2.50	$0.41	$1.75	$0.82	$2.75	$ 3.500	
										3.350	
										0.717	
										2.255	
										9.822	$0.364
		1:1.5:3	3.50	1.71	2.50	0.39	1.75	0.78	2.75	3.500	
										4.275	
										0.683	
										2.142	
										10.600	0.393
JOINT COMMITTEE.	1 500 lb.	1:2.4:3.5	3.50	1.40	2.50	0.52	1.75	0.76	2.75	3.50	
										3.50	
										0.91	
										2.09	
										10.00	0.370
	2 000 lb.	1:1.8:2.9	3.50	1.75	2.50	0.48	1.75	0.78	2.75	3.50	
										4.375	
										0.840	
										2.141	
										10.856	0.402
	2 500 lb.	1:1.3:2.4	3.50	2.20	2.50	0.43	1.75	0.80	2.75	3.500	
										5.500	
										0.753	
										2.200	
										11.953	0.443

Table 9 is similar to Table 8, except that it is worked out on the basis of a Joint Committee requirement for three classes of concrete, namely, 1 500 lb., 2 000 lb., and 2 500 lb.

TABLE 8.—New York Building Code.

	Percentage of vertical reinforcement, p	Percentage of spiral reinforcement, p'	Concrete and vertical steel carry, (1) $500(1+14p)$ (2) $600(1+11p)$	Spiral carries, $40\,000 \times p'$	Total bearing value of concrete core including spiral, pounds per square inch. f_c	Area of core required to carry load of 1 000 000 lb. $\frac{1\,000\,000}{f_c}$	Cost per Cubic Foot of Core, in Cents. $(1-p) \times 100 \times$ cost of concrete.	$p \times 144 \times 3.4 \times 4 = 1\,960\ p$, vertical steel.	$p' \times 144 \times 3.4 \times 5.5 = 2\,690\ p'$, spiral steel.	Total cost of concrete and steel per cubic foot, C	$0.695 \times \frac{C}{f_c}$ cost of core, in dollars, for a load of 10 000 lb.
1: 2: 4 Concrete, $f_c = 500$ lb. per sq. in., $n = 15$.	1	½	570	200	770	1 300	36.0	19.6	13.45	69.05	$0.0625
	2	"	640	200	840	1 190	35.7	39.2	13.45	88.35	0.0730
	3	"	710	200	910	1 100	35.3	58.8	13.45	107.55	0.0822
	4	"	780	200	980	1 020	34.9	78.4	13.45	126.75	0.0900
	1	1	570	400	970	1 030	36.	19.6	26.9	82.5	0.0590
	2	"	640	400	1 040	960	35.7	39.2	26.9	101.8	0.0678
	3	"	710	400	1 110	902	35.3	58.8	26.9	121.0	0.0757
	4	"	780	400	1 180	850	34.9	78.4	26.9	140.2	0.0826
	1	1½	570	600	1 170	855	36.	19.6	40.35	95.95	0.0570
	2	"	640	600	1 240	807	35.7	39.2	40.35	115.25	0.0646
	3	"	710	600	1 310	764	35.3	58.8	40.35	134.45	0.0712
	4	"	780	600	1 380	725	34.9	78.4	40.35	153.65	0.0773
	1	2	570	800	1 370	730	36.	19.6	53.8	109.40	0.0555
	2	"	640	800	1 440	695	35.7	39.2	53.8	128.70	0.0620
	3	"	710	800	1 510	663	35.3	58.8	53.8	147.90	0.0680
	4	"	780	800	1 580	632	34.9	78.4	53.8	167.1	0.0735
1: 1½: 3 Concrete, $f_c = 600$ lb. per sq. in., $n = 12$.	1	½	666	200	866	1 155	38.9	19.6	13.45	71.95	0.0576
	2	"	732	200	932	1 072	38.5	39.2	13.45	91.15	0.0680
	3	"	798	200	998	1 010	38.1	58.8	13.45	110.85	0.0770
	4	"	864	200	1 064	940	37.7	78.4	13.45	129.55	0.0845
	1	1	666	400	1 066	938	38.9	19.6	26.9	85.4	0.0556
	2	"	732	400	1 132	884	38.5	39.2	26.9	104.6	0.0640
	3	"	798	400	1 198	835	38.1	58.8	26.9	123.8	0.0718
	4	"	864	400	1 264	792	37.7	78.4	26.9	143.0	0.0787
	1	1½	666	600	1 266	790	38.9	19.6	40.35	98.85	0.0542
	2	"	732	600	1 332	750	38.5	39.2	40.35	118.05	0.0616
	3	"	798	600	1 398	715	38.1	58.8	40.35	137.25	0.0682
	4	"	864	600	1 464	682	37.7	78.4	40.35	156.45	0.0743
	1	2	666	800	1 466	680	38.9	19.6	53.8	112.3	0.0533
	2	"	732	800	1 532	652	38.5	39.2	53.8	131.5	0.0596
	3	"	798	800	1 598	625	38.1	58.8	53.8	150.7	0.0655
	4	"	864	800	1 664	601	37.7	78.4	53.8	169.9	0.0710

TABLE 9.—JOINT COMMITTEE SPECIFICATIONS.

$n = 15$ for $f'_c = 1\,500$ lb. and $2\,000$ lb.

$n = 12$ for $f'_c = 2\,500$ lb.

Percentage of ultimate compressive strength of concrete.	Percentage of vertical reinforcement.	Percentage of spiral reinforcement.	$f_c = 300 + (0.10 + 4\,p)\,f'_c$, stress on core.	$f_c\,(1-p)$, Bearing value of concrete per square inch.	$n \times f_c \times p$, Bearing value of steel per square inch of core.	F_c Total bearing value per square inch of steel and concrete.	$\frac{1\,000\,000}{f_c}$ Area of core required to carry a load of 1 000 000 lb., in square inches.	Cost per Cubic Foot of Core, in Cents. $(1-p) \times 100 \times$ cost of concrete.	Cost per Cubic Foot of Core, in Cents. $p \times 144 \times 3.4 \times 4 = 1\,960\,p$ (vertical steel). $\frac{1}{4} \times p \times 144 \times 3.4 \times 5.5 = 672.5\,p$ (spiral steel). $2\,632.5\,p$, total cost of steel.	Cost per Cubic Foot of Core, in Cents. C, cost of concrete and steel per cubic foot.	$0.695 \times \frac{C}{f_c}$, cost of core, in dollars, for a load of 10 000 lb.
$f'_c = 1\,500$ lb. per sq. in.	1	¼	510	505	76.5	581.5	1 720	36.6	26.33	62.93	0.0754
	2	½	570	558	171.0	729.0	1 370	36.2	52.65	88.85	0.0847
	3	¾	630	610	284 0	894.0	1 120	35.8	78.98	114.78	0.0890
	4	1	690	663	414.0	1 077.0	930	35.5	105.30	140.80	0.0907
	5	1¼	750	712	563.0	1 275.0	785	35.2	131.63	166.83	0.0910
$f'_c = 2\,000$ lb. per sq. in.	1	¼	580	575	87.0	662.0	1 510	39.8	26.33	66.13	0.0695
	2	½	660	646	198.0	844.0	1 183	39.4	52.65	92.05	0.0760
	3	¾	740	717	333.0	1 050.0	952	39.0	78.98	117.98	0.0780
	4	1	820	786	492.0	1 278.0	785	38.6	105.30	143.90	0.0782
	5	1¼	900	855	675.0	1 530.0	653	38.2	131.63	169.83	0.0771
$f'_c = 2\,500$ lb. per sq. in.	1	¼	650	643	78.0	721.0	1 390	43.8	26.33	70.13	0.0677
	2	½	750	735	180.0	915.0	1 094	43.5	52.65	96.15	0.0730
	3	¾	850	825	306.0	1 131.0	883	42.9	78.98	121.88	0.0746
	4	1	950	912	465.0	1 367.0	732	42.5	105.30	147.80	0.0752
	5	1¼	1 050	998	630.0	1 628.0	615	42.0	131.63	173.63	0.0742

In Table 10 are given: (1) the costs of the 2-in. concrete protective shells outside of the spiral for different core areas and different classes of concrete; and (2) the diameter of the columns outside of the shells in terms of the core area.

TABLE 10.—COST OF 2-IN. COVERING.

Formula for Volume of Covering.

Area of Covering $= \pi\ (R + 2)^2 - \pi R^2 = 4\ \pi (R + 1)$, in Square Inches.

$$\pi R^2 = A. \quad R = \sqrt{\frac{A}{\pi}} = 0.0873\ (R + 1), \text{ in Square Feet.}$$

Volume per Foot of Column : $0.0494 \sqrt{A} + 0.0873$.

Area of core.	Constant.	New York Code.		Joint Committee.			Diameter of core $1.18 \sqrt{A}$, in inches.
		1 : 2 : 4 (0.364)	1 : 1½ : 3 (0.393)	1 500 lb. (0.370)	2 000 lb. (0.402)	2 500 lb. (0.443)	
100	0.5813	0.212	0.229	0.215	0.234	0.258	11.3
200	0.7823	0.285	0.308	0.290	0.315	0.347	16.0
300	0.9423	0.344	0.371	0.349	0.379	0.417	19.6
400	1.0723	0.391	0.422	0.397	0.432	0.475	22.6
500	1.1903	0.435	0.470	0.441	0.480	0.529	25.2
600	1.297	0.471	0.509	0.479	0.521	0.574	27.6
700	1.397	0.507	0.548	0.516	0.561	0.619	29.9
800	1.482	0.540	0.581	0.550	0.596	0.656	32.0
900	1.567	0.570	0.616	0.580	0.630	0.695	33.9
1 000	1.647	0.598	0.645	0.606	0.662	0.727	35.7
1 100	1.727	0.627	0.677	0.638	0.694	0.764	37.5
1 200	1.797	0.652	0.705	0.664	0.722	0.795	39.1
1 300	1.867	0.680	0.732	0.690	0.750	0.825	40.7
1 400	1.937	0.704	0.760	0.715	0.777	0.860	42.3
1 500	2.000	0.728	0.786	0.740	0.804	0.886	43.7
1 600	2.063	0.750	0.810	0.762	0.830	0.912	45.2
1 700	2.127	0.774	0.835	0.788	0.855	0.945	46.5
1 800	2.185	0.795	0.855	0.805	0.877	0.965	48.0
1 900	2.244	0.820	0.885	0.834	0.905	0.995	49.2
2 000	2.297	0.834	0.900	0.847	0.925	1.015	50.5

The general conclusions derived from Tables 6 to 9 are:

1.—That the columns constructed with the strongest concrete are the cheapest, whether designed in accordance with the New York Code or the Joint Committee report.

2.—That the "Joint Committee" columns do not vary materially in costs with the percentage of steel used.

3.—That the largest "Joint Committee" column is the cheapest.

4.—That the cheapest New York Code column is the one with the maximum percentage of spiral and minimum vertical steel and that the "Joint Committee" columns of approximately equal size and capacity cost fully 30% more.

5.—That the largest New York Code columns cost approximately 25% less than the "Joint Committee" columns of equal size and capacity.

6.—That the smallest New York Code column costs about 6% less than the smallest "Joint Committee" column.

7.—That the difference in diameter between the smallest and cheapest New York Code column is small, about 1 in. for 400 000-lb., and 2 in. for a 1 000 000-lb. column.

8.—That the cheapest "Joint Committee" column costs nearly 30% more than the cheapest New York Code column and that the size of the "Joint Committee" column is much greater than the New York Code column. For 1 000 000 lb. capacity, the ratio being 46 in. to 34 in. in diameter, or approximately 84% larger in area, an important factor when available floor space is considered.

The general conclusion is, that the Joint Committee requirements increase the cost of columns from 25 to 30% above the cost of the columns now used in New York City. The cost of the interior columns in a reinforced concrete skeleton is approximately 12% of the total and the increased cost of the columns mentioned previously, results therefore, in an increase of 3 to 4% in the cost of the entire structure.

In the absence of proper data, it was found impossible to discover the reason for the necessity of this increase in cost, and it would be most illuminating to have pointed out, by those who are familiar with the origin of this new column formula, the reasons which prompted the Joint Committee in recommending a design, the cost of which is so much greater than that of the present design practice in New York City.

EDWARD GODFREY,* M. AM. SOC. C. E.—There are some places in the report where a little change or addition would add to the clarity. Among the definitions there should be added one of Compression Surface. As used in this report, the compression surface is the surface of a beam or slab on the compression side. Section 118 speaks of the flange of the slab. This is not clear. The flange of the T would be better.

There should be a section in the first part of the report calling attention to the Standard Notation in Appendix I. The speaker discovered many symbols that were not defined.

Determination of the area of deformed bars by the minimum cross-section thereof (page 73)† is a good requirement.

The 1½ min. for batch mixing is a good requirement. It is seldom realized on a job. "Batch a minute", the common slogan, means at best about 40 sec. of mixing.

The cold weather precautions are good, since they limit the temperature to which materials are heated. Much poor work is due to the use of hot materials.

It is well that the report does not sanction clamps as a splice for rods. Clamps do not hold rods firmly enough to prevent the first slip, and the first slip is the beginning of trouble that may prove serious. Sharp bends in rods are also prohibited. It would be better, however, to require the radius of the bend to be more than four diameters.

Integral compounds are not permitted. Good workmanship and good concrete are recommended for water-proofing concrete instead. However, high compressive strength is generally of subordinate value where water-proof qualities are of prime necessity. The slump test recommended in the report

* Structural Engr. (Robert W. Hunt & Co.), Pittsburgh, Pa.

† *Proceedings*, Am. Soc. C. E., August, 1921.

for massive concrete is only 2 in. This would require a stiff concrete that would have a strength massive concrete seldom if ever needs, but it would lack in water-proof qualities, qualities desirable or necessary in most massive concrete.

The provision is good that in two-course paving work the wearing surface must be placed within ½ hour after the base course. It would be well for every concrete sidewalk expert to remember this. Much bad paving work is the result of allowing the base course to set hard before the finish course is placed.

In Section 110, there is a reference to beams or slabs cast monolithic with "columns or similar supports". Such parts are given a large advantage over other continuous slabs or beams. One can understand how a line of continuous beams cast monolithic with good stiff lower-story columns will be stiffened by the columns, but why a slab that happens to be cast monolithic with the column should have any decided increase in strength is hard to understand. It is not at the ends of a span, adjacent to the columns, where the report gives the advantage; it is at the mid-span where a 50% advantage is given in beams and slabs because of the nature of the supports. What is meant by supports similar to a column? If a girder or beam is meant, in what way are these similar to a column? If the Committee meant to give a slab a 50% advantage because of monolithic support on a girder, this would mean that the girder is in torsion at the support, an untenable proposition. Section 110 needs clarifying. It needs some basis of fact or analysis to justify and sustain it. In the matter of unit stresses the report departs radically from accepted standards.

In this discussion the speaker shall assume a 2 000-lb. concrete for simplicity and more ready comparison with other standards. As an example of the difference in the standard of this report and that of the 1916 Report, take the case of a beam or slab continuous and poured monolithic with the support. The 1916 Report allowed for a moment, $\frac{w\,l^2}{12}$. This report allows $\frac{w\,l^2}{16}$. The 1916 Report allows 650 lb. of unit stress in the concrete; this one allows 800 lb. Combine these ratios and the result is 39:64. There should be full explanation of this enormous degradation of design standard. A design based on the new report would have to be increased 64% in strength to meet the standard of the 1916 Report.

The provisions of the report as to the proportions of concrete can scarcely be expected to satisfy any one accustomed to coming in contact with the practical work of making concrete. Suppose, for example, 2 000-lb. concrete is desired, and the size of aggregate varies from ¼-in. to 1½-in., the sand passing a ¼-in. sieve. This is usual for small structural parts. The mixture recommended in the report is 1 : 1.7 : 3.4. The contractor is accustomed to measuring his quantities in units, or half-units at the most. His men are familiar with a wheelbarrow loaded with 2 cu. ft. of sand or gravel, and a load of 1.7 cu. ft. would mean trouble and extra expense. All batches would have to be smaller than the usual 1 : 2 : 4 batch, but, the work of making the batch would be practically the same.

Of course, the contractor might find a nearly 1:2:4 mix with $\frac{1}{8}$-in. sand and a slump of 3 to 4 in. This would mean that he would have to screen the sand on a $\frac{1}{8}$-in. screen and use a concrete so stiff that it would not flow around the reinforcement. This would mean added expense, and the work would suffer, for the fluidity of the concrete is of more importance than its strength in a compression test. The speaker recently examined a comparatively new reinforced concrete arch bridge where the concrete evidently had been too stiff to flow properly around the reinforcement. The county engineer is contemplating digging out large quantities of this concrete in an effort to correct the serious error in the construction of the bridge, namely, the use of stiff concrete.

In Section 71, with regard to joints in floors, the report states, "Adequate provision shall be made for shear either by sufficient reinforcement or by sloping the joint, so as to provide an inclined bearing". The joints referred to are to be located near the center of span. What shear that needs reinforcement near the center of a span or how shear can be taken care of by "sloping the joint so as to provide an inclined bearing" are points that need elucidation. It is compression that demands consideration in the middle of the span of beams and slabs, and feathered edges or sloping joints induce failure by diagonal shear due to the sloped joint. No engineer would splice a column by cutting the butting ends on a diagonal.

In the matter of the consistency of concrete, the economy and convenience of making the concrete, items that should engage the engineer's attention, have been ignored. For mass concrete a slump test of 2 in. is recommended. The object of the specifying of this stiff concrete is manifestly to secure a concrete of high compressive strength. Density and integrity of the concrete are the essentials in practically all mass concrete, and these are obtained by using a freely flowing, liquid concrete. The stiff concrete recommended could neither be chuted economically nor puddled in the forms. The conditions of a laboratory, where a class of students perform a large amount of work on a small quantity of concrete, are no criterion of conditions in construction, where a small amount of hand work must be performed on a large amount of concrete or costs mount up to prohibitive proportions.

Failures in concrete due to compression are rare; failures or unsightly appearance of structures due to rusting of steel are common. It is not meant here to state that failures in columns are rare. Failures in rodded columns are common, due to the absence of tensile reinforcement to give toughness.

Doubtless much of the supposed justification of the methods of design, in the report, such as those for footings, stirrups, flat slabs, and other forms of design, is the result of strain-gauge measurements of the stress in steel. These test results, as commonly interpreted, are misleading for two reasons, as follows: (1) If the concrete is not cracked, the strain-gauge measurement is simply the stress that the steel takes while the surrounding concrete is receiving a tension from four to six or more times as much as the steel rod. When the concrete cracks, the steel receives all of it; and (2) if the concrete is cracked, say, at one point in the space in which the strain is measured, the result is the stretch of (1) plus a little additional stretch in the crack where the stress is possibly five or ten times as great as it is in

the uncracked portion. Only the average strain is measured, and the actual stress per square inch may be many times as much as the strain-gauge reading would indicate. In the face of these undeniable facts, it is strange that engineers should treat seriously the experimental results thus universally falsely interpreted and on the strength of this false interpretation, ignore the principles of mechanics on which all structural design must be based.

There is no method known for determining even approximately the tension on a rod embedded in concrete, unless the concrete is entirely whole, in which case the result has little meaning, or unless the rod is severed of its grip on the concrete for the entire length in which the stretch is measured. This simple fact vitiates a great deal of painstaking and laborious work and much of the standard practice of designing based on the misinterpreted results of that work, in contravention of established principles of statics and mechanics.

In its rules for the designing of a counterforted retaining wall, a new feature in the report, the Committee errs in recommending that the counterfort be treated as a triangular beam instead of what it really is, or should be, namely, concrete covering of anchor rods tying the horizontal and the vertical slab together.

The recommendations of the report do not give sufficient reinforcement to provide for bending resistance equal to the bending moments in the floor slabs. This deficiency is a very substantial one. A design on this standard would have to be increased 19% to meet the standard of the 1916 Report.

Mr. Slater* in a recent discussion of the report is compelled to acknowledge that the moment coefficients of the report fail to reinforce the flat slab for the moments which it must receive. He attempts to justify the low coefficients of this report by saying that tension in the concrete helps out the flat slab in a manner not exhibited in ordinary beams and slabs. The speaker is willing to concede this up to a certain point, and that is where the flat slab is identically conditioned with the ordinary slab between beams.

The simplest analysis proves that certain total bending moments must be resisted along three lines. One of these lines is midway between rows of columns; the other two are tangent to the column heads and parallel to the first. If a flat-slab floor was critically loaded, cracks could occur along these three lines. The slab would be conditioned with an ordinary continuous slab on girders. Why is the flat slab not reinforced for this condition, where tension in the concrete is no more favorable to the flat slab than to the ordinary slab?

No critical test has ever been made and published on a flat-slab floor. Tests have been made that in some respects are severe, but no tests have been made on a complete row of bays across a building from one side to the other nor on a complete row of bays along the outside of a building. Furthermore, the conclusions that have been drawn from tests on flat slabs are based on strain-gauge measurements on steel rods embedded in concrete. The speaker has already proven that these measurements tell nothing of definite value; as made, they cannot show the real stress in the steel.

* *Proceedings*, Am. Soc. C. E., September, 1921, p. 243.

It is to be noted that the unit stress allowed on rodded columns is reduced, and the "wires" are now required to be ¼ in. in diameter and not more than 8 in. apart. It is impossible for any stress to develop in square-shaped ties that would tax ¼-in. steel rods. In the list of twenty-nine failures that the speaker recently published, rodded columns failed at units as low as 150 lb. per sq. in.

On spirally reinforced columns the report allows a greater unit stress on the upright steel for increased percentage of that steel. Earlier standards and some standard works allow column stress on the spiral reinforcement. This seems to be an effort to effect the same thing through the medium of the upright steel, as the spiral steel varies in general with the upright steel. Both these methods are in error for the reason that neither calls for any variation in the pitch for varying unit stress. It is true that by making the pitch of the coil closer, the compressive strength of the column is increased because there is thus created a flatter concrete disk.

It can have no effect on the strength of a column, in a column where the coil is not deficient, to increase the sectional area of the coil wire without decreasing the clear distance between coils; it can have no more effect on the strength of the column than increase in the size of lattice bars of a steel column could have on a column the lattice bars of which are not deficient. This is sound logic, and tests do not in any manner contradict it.

What is needed in the way of a standard for hooped columns is a definite relation between the size of the column and the pitch and section of the coil and a definite unit value for this standard column, varying with the ratio of slenderness of the column.

The use of rodded columns should be eliminated, except for such conditions as where a cast-iron post would be appropriate in steelwork, and then only for chunky columns. Rodded columns are not suitable for monolithic work, because monolithic work means bending moments in columns.

The hooped column with a cast-iron core doubtless gives high test values, but the beam and girder connections and splices for the cast-iron core present difficulties exceedingly hard to overcome. A column splice in a building must be capable of taking tension or bending stresses. The only general collapse on record of a high metal cage building was one having cast-iron columns. If it is proposed to use flanges on the cast-iron core, these would occupy the space of the surrounding concrete and destroy its continuity and that of the spiral. Furthermore, if the milling on the ends of cast-iron cores were inexact, an open space would be left, and the high stress of the cast iron thrown on the concrete shell with disastrous results.

Almost for the first time in any standard, bent-up and anchored rods are recognized as a method of reinforcing for shear. Coupled with this allowance, however, there is a restriction that tends to nullify it as an available means of reinforcement. The idea of a stirrup or sharply bent-up rod as the only thing that could possibly take shear, is exceedingly hard to kill. It was this idea that induced the committee of the American Concrete Institute in its first draft of the 1920 Report to restrict the angle of bent-up rods to inclinations between 30° and 60° with the horizontal. There is far more reason

for the upper limit of the angle to be 20° or 30° than for the lower limit to be near this value. The bent-up and anchored rod must reach from the first section where shear reinforcement is needed to the face of the support.

The Committee also discourages flat slopes in reinforcing rods in Section 156, where it is stated, "mere sagging of the bars shall not be permitted". In the speaker's judgment this is a grave error and forbids a practice that is very beneficial. Sagging of bars and flat slopes have proven more effective in construction than any stirrup system or sharply bent-up rods, for the same weight of steel. The flat bend and the sagged rod can be analyzed; the stirrup and sharply bent-up rod cannot be analyzed.

If the bent-up and anchored rod, like the stirrup, was designed for a flat stress, which its sponsors confess it can never take until the surrounding concrete has failed, a stress that no analysis can justify, there might be a reason for limiting the angle of the bend so as to avoid too high a tensile unit stress. The rods, however, are, by this report, designed for a stress that is subject to rigid analysis, and the flatter the angle the greater the stress. There is, therefore, no danger of over-stress and no manifest reason for limiting the angle of the bend to any minimum whatever.

The speaker has had exceedingly good results in more than one test of buildings in which bent-up and anchored rods were used as reinforcement and which had a flatter angle than that permitted by this report. In two buildings with this type of shear reinforcement, excess load on the floor failed to produce any cracks. In another building, in which the concrete was poor and where rebuilding was seriously considered, although a few cracks developed in the beams, the test results were so good under an excess load, in the matter of deflection, that the structure was saved and pronounced good for its design load. It is inconceivable that this floor could have stood the same test with straight rods and stirrups. The speaker's tests on another building with beams so reinforced, demonstrate this.

In *Bulletin No. 64,* University of Illinois Experiment Station, Professor Talbot reports tests on two buildings with beams having bent-up and anchored rods as well as others where sharply bent-up rods, not anchored, were used. No cracks were found in the beams in which rods were bent and anchored, and high stress was observed in the rods, which shows that they were performing their function. Cracks were observed in the beams reinforced in the standard way for shear. The bends of the anchored rods showing the best results were in many cases flatter than 20 degrees.

Another notable statement in the report is found in a footnote, on page 93,* Section 129. The footnote attempts to justify the exceedingly high unit shear value allowed on stirruped beams, namely, 12% of the ultimate strength of the concrete; and it even intimates that this is conservative. The notable part of the statement is that stirruped beams with 50% of the ultimate strength as a shear value fail "due to diagonal compression in the webs". Published tests† gave this stress which is here called "diagonal compression in the

* *Proceedings,* Am. Soc. C. E., August, 1921.

† *Engineering News-Record,* February 27th, 1919.

webs" as shear in the nominal webs. The speaker recently pointed out that the freak beams of these tests were not subject to shear in their webs near the time of failure, but to diagonal compression.

The peculiar form and reinforcement of these concrete I-beams and the opportunity for anchorage of the horizontal rods in the I-beam heads made it possible for the beams to carry a large load by diagonal compression in the web, but the ordinary beam is far from being in the same class. Hence, the absurdity of this footnote and this high unit load. The use of a "safe" unit shear that is equal to the unit at initial failure in shear, as observed in these tests, should need no comment. The fallacy of this is rendered more apparent when it is pointed out that this initial point of failure in shear was measured by considering only a part of the cross-section of the beam subject to shear.

The anchorage of stirrups and short shear members, required by the report, makes these members still more troublesome in pouring concrete. Every practical builder realizes what this means and would welcome the elimination of stirrups.

R. C. R. Gautier,* Assoc. M. Am. Soc. C. E.—The speaker would like to say a few words in favor of rodded columns. All engineers who design buildings, particularly industrial buildings, know that in designing rectangular wall columns, it is neither convenient nor practical to use hooped columns for such sections. The average size of columns in industrial buildings is about 24 to 30 in. wide by 14 to 18 in. deep. If designers were compelled to use hoops, in such columns, they would have to use two small separate units of hooping, and one-third to one-half of the concrete area would not be utilized, theoretically. It was the speaker's privilege to work on some reinforced concrete designs in France and England, and, as Considére has a patent on hooped columns in those countries, rodded columns are almost universally used, with excellent results as far as one is able to judge by the hundreds of buildings that have been built with no failure. Furthermore, designers in those countries use for a 1:2:4 concrete, or the equivalent mixture, a stress of approximately 600 lb. per sq. in., and, since they obtain good results, it seems that their experience should not be disregarded. Granting that in those countries, concrete is poured with much more care than in the United States, and that here, such a high stress should not be assumed, the speaker sees no reason why the stress of 500 lb. per sq. in., which has been used successfully for many years, should be abandoned and replaced by 400 lb. per sq. in., as proposed in the new specifications.

Mr. Loney spoke about the position of the engineer, who would be confronted with the task of telling an owner that a building constructed according to the proposed recommendations of the Joint Committee, would cost 10% or 11% more than a building designed according to other specifications. The speaker thinks it is well to point out also that, regardless of the cost, the engineer, having to make such a statement to an owner, will be placed in a very awkward position as far as his professional standing is

* Chf. Engr., Thompson & Binger, Inc., New York City.

concerned. In many cases, an owner wishes to duplicate a building and he goes to the same engineer for plans. If the proposed regulations are made a standard for the whole country, it is possible that the engineer will have to make an entirely different design from the one he made several years ago. Consider the question of columns only, should they be designed for a stress of 400 lb. per sq. in. instead of 500 lb., the size of the interior columns of a building might have to be increased from 14 by 14 in. to 16 by 16 in., and the depth of the wall columns might have to be increased from 14 in. or 16 in. to 18 in. or 20 in. Naturally, the owner would ask for the reasons and the engineer would be placed in the position of replying that the building, designed for him five years ago, was not strong enough; that a committee of engineers have decided that the stresses used in designing his building were too high, and lower stresses have to be used for safety. The owner will either discharge his engineer as being incompetent, or tell him he is a fool, for the building which was designed according to his computations of several years ago, stands well under the load for which it was designed, or, perhaps, a greater load.

In connection with flat slabs, the proposed specifications call for moment coefficients which would give results slightly higher than those given by the Chicago Building Code, for four-way slabs, and, since a number of flat slab buildings have been built satisfactorily in accordance with this code, and since the New York City authorities have recently adopted a code which is a little more liberal than the Chicago Building Code, it seems hardly necessary to take a retrogressive step and ask designers to provide more steel than is called for by either of these building codes. All engineers are undoubtedly familiar with the test required by the Chicago Building Code: Under twice the live load, two consecutive panels should not show a deflection larger than $\frac{1}{800}$ of a span. It is a pretty stiff specification, and, yet, in most cases, tests, so made, will show that no such deflection occurs. The speaker has made tests on buildings designed and built by his company, and his practice is to load one panel instead of two, which load would tend to increase the deflection in the center of the panel. It is unusual to obtain, under such loading, a deflection greater than $\frac{1}{1800}$, or $\frac{1}{2000}$ of a span, although the flat slab buildings referred to are designed with coefficients smaller than those recommended by the Chicago Building Code.

In conclusion, it appears that the tentative specifications, so far as columns and flat slabs are concerned, seem a step backward instead of forward, and in view of the fact that, with falling costs of structural steel, concrete is already at a disadvantage when placed in competition, it does not seem fair to handicap it further. Every one is interested in good buildings, but it is believed that, at the present moment, much more can be done by placing emphasis on inspection than by trying to prevent failures by increasing the calculated coefficient of safety.

W. A. SLATER,* Assoc. M. Am. Soc. C. E.—The slab moment coefficient is almost the same as the "Chicago" moment coefficient. The difference lies in

* Engr.-Physicist, U. S. Bureau of Standards, Washington, D. C.

the slab thickness rather than in the moment coefficient. There is a minimum thickness formula given, which requires, generally, a somewhat greater thickness than the Chicago Building Code. The results of tests* indicate that the factor of safety is sufficiently large to warrant using this moment coefficient as a basis for designing the reinforcement.

It is possible, however, that a slab which has a sufficiently high factor of safety against collapse may give objectionably large deflections under long continued loading and the data available do not indicate what the limits are in this direction. The slab thickness formula was, therefore, made such that when the column capital has a diameter of 0.225 times the span, the thickness would be nearly the same as that given by the slab thickness formula recommended by the 1916 report of the former Joint Committee. This is believed by the speaker to represent the consensus of good practice and to be satisfactory to the majority of engineers. Rationally, a thickness formula should take into account the size of the column capital, the negative moment resisted within the column strip, and the width of the depressed panel (since the compression due to the negative moment in the column strip must be resisted in that width). The formula proposed introduces these factors.

For this discussion let it be assumed that (1) the "parabolic formula" gives accurately the compressive stress in the concrete; (2) that the true strength of the concrete is given by the cylinder tests; and (3) that the "straight line formula" is used for design.

With an allowable working stress in the concrete of 45% of its cylinder strength, the factor of safety of such a beam against compression failure would be a little more than 3. Assuming that, with long continued or repeated loads, failure of the beam might occur at a stress equal to two-thirds of the ultimate cylinder strength, the factor of safety would be reduced to two-thirds of 3 or 2. Recognizing as allowable a working stress of 16 000 lb. per sq. in. in steel, which may have a yield point as low as 33 000 lb. per sq. in., is in effect recognizing the adequacy of a factor of safety of 2.06 (33 000 divided by 16). It will be seen, therefore, that the accepted factor of safety for structural steelwork is no greater than that which would be furnished by a concrete beam that uses 45% of the cylinder strength as a working stress; even though the beam fail at a compressive stress only two-thirds of the cylinder strength, it would be as great as that which is recognized as being necessary in structural steelwork.

It is not necessary, however, to resort to this reasoning entirely as justification for this allowable working stress. A paper based on results of tests carried out by the Technologic Branch of the U. S. Bureau of Mines at St. Louis, Mo., reports results of tests of seventy-one reinforced concrete beams, most of which had 3% of reinforcement and all of which failed by compression. It may be seen from this paper, that the factor of safety was well above the theoretical value in most cases and that for the weaker concretes it was the highest.

* Westergaard and Slater "Moments and Stresses in Slabs", *Proceedings*, Am. Concrete Inst., Vol. 17 (1921), p. 508.

If, as assumed, a beam failed when the compressive stress by the parabolic formula was equal to the cylinder strength, the stress at the maximum load by the straight line formula would be approximately 1.4 times the cylinder strength (1.4 times the stress by the parabolic formula) or 1.05 times the cube strength (assuming the strength of a cylinder, the height of which is twice its diameter, to be 75% of the strength of a cube of the same concrete). Many data are available, which indicate that the flexural strength of the concrete computed by the straight line formula is at least 1.4 times the cylinder strength, or 1.05 times the cube strength. Many of the tests show even a greater strength.

The following are references to literature bearing on the relation between compressive strength of concrete in beams and the compressive strength in direct compression specimens:

(1) Slater and Zipprodt, "Compressive Strength of Concrete in Flexure", *Proceedings*, Am. Concrete Inst., Vol. 16 (1920), p. 120.

(2) Taylor and Thompson, "Concrete Plain and Reinforced", 3d. ed., p. 416.

(3) Turneaure and Maurer, "Principles of Reinforced Concrete Construction", 2d ed., p. 154.

(4) *Bulletin 175,* Univ. of Wisconsin, by M. O. Withey, p. 28. (Compressive stresses computed by parabolic formula. Cubes used as control specimens).

(5) *Bulletin No. 197,* Univ. of Wisconsin, by M. O. Withey, p. 89. (Compressive stresses computed by parabolic formula).

(6) "Der Eisenbetonbau", by E. Mörsch, 4th ed., p. 167. (Tests by F. von Emperger about 1903).

(7) Handbuch für Eisenbetonbau, 3d. ed., Vol. I. (Cubes used as control specimens); (*a*) p. 207, Tests by Sanders about 1902; (*b*) p. 208, Tests by Schüle about 1906; (*c*) p. 210, Tests by Bach and Graf, 1907 to 1920 (T-beams included in this investigation); (*d*) p. 235, Tests by Bach und Graf about 1912; (*e*) p. 238, Tests for the use of the Austrian Committee on Reinforced Concrete, 1917.

Reference No. 1, the largest investigation of any of those cited, gives results of seventy-one beams all of which failed by compression. The beams contained approximately 3% of reinforcement and, in all cases, the stress at the maximum load, computed by the straight line formula, was considerably greater than the cylinder strength. The weaker the concrete the higher, in general, was the ratio of the beam strength to the cylinder strength.

On the question of the necessity of assuming that failure under repeated loads may occur when the stress in the concrete is only two-thirds of the strength for a single application of load, tests made at the Bureau of Standards give some indication.* Of the four beams tested to failure, all the failures were by tension in the reinforcement and none by compression in the concrete, although the stresses in compression were no higher, in proportion to the ultimate strength of the concrete, than the stresses in the tension in proportion to the yield point of the steel.

It does not seem illogical that the ultimate strength of the concrete should be taken as a criterion of the ultimate strength of the beam, at the same time that the yield point of the steel is taken as a criterion of the ultimate strength

* Slater, Smith, and Mueller, "Effect of Repeated Reversals of Stress on Double Reinforced Concrete Beams", *Technical Paper No. 182*, National Bureau of Standards.

of the beam. The rate of deformation in the steel after the yield point is passed is generally so great that excessive compressive stresses are thrown upon the "extreme fiber", bringing about a crushing failure very shortly after the yield-point stress in the reinforcement is reached. On the other hand, the rate of increase in the deformation of the concrete is much more gradual with high loads and the ultimate strength in compression may be reached without an abnormal increase in the tensile stress.

Looking at the question from all sides, it seems that there are sufficient data to justify permitting a flexural compressive stress, at positions of positive moment, of 40% of the cylinder strength of the concrete and 45% for positions adjacent to the support of continuous beams.

A. N. Talbot,* Past-President, Am. Soc. C. E.—The allowable working stress in compression in flexure for 2 000-lb. concrete is given as 800 lb. per sq. in. at the positive bending moment section and 900 lb. per sq. in. at the negative bending moment section. It seems that this proposed working stress deserves consideration. It should be recognized that the factor of safety, using this term to mean the ratio of the ultimate load that the beam may be expected to carry and the load that will produce the nominal working stress, is considerably more than the ratio of the working stress and the assumed ultimate compressive strength of the concrete; in other words, in this case, more than 2 000 to 800, or 2.5. There are other conditions entering into this: First, the stress-strain relation which is not a straight line, but has more of the form of a parabola. With this curved relation, the ultimate load-carrying capacity is increased beyond what is given by the accepted straight-line formula used for simplicity and not because it represents the actual condition in the beam. This change would perhaps make the safety factor 3.0 or possibly more, instead of 2.5. The second condition to be considered, is that when concrete is in compression in flexure the actual amount of strain or deformation before failure occurs is markedly more than for direct compression. Concrete will fail in direct compression when it reaches a strain of about 0.0013, corresponding in amount to the stretch in steel at 39 000 or 40 000 lb. per sq. in. When the beam is subjected to flexure the failure of the concrete will not occur until a considerably increased shortening occurs, say, twice as much as that at failure in direct compression; this gives a further margin of safety. Perhaps at the upper fiber there will be no added resistance over that at a strain of 0.0013, but the same resistance may be expected to continue. At some point below the upper fiber the resistance developed may be as great as at the upper fiber. Perhaps this feature may add 20%, thus altogether developing a ratio of 3.5 to 4.00, or in the neighborhood of this.

The real margin then for loading once applied would be considerably greater than the 2.5 of the calculation. On the other hand, when concrete is subjected to high stresses repeatedly, even a few times, it will fail at loads lower than that required to give failure on first application. For buildings, the value used should certainly not be more than two-thirds or three-

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fourths of that which would be used for a load once applied. Two-thirds of the factor of 3.5 or 4.0 would bring the factor to about 2.5. It may then be considered that 800 lb. per sq. in. will result in a factor of safety of about 2.5 with concrete of 2 000 lb. per sq. in. This is about the same ratio as is found for the steel in tension with 16 000 lb. per sq. in. working stress as compared with 40 000 lb. per sq. in. yield point for mild steel bars of ordinary size. The question would then arise whether it is desirable to allow no more margin of strength for the concrete than for the steel; and it would seem that this is a question that should have careful consideration.

Bearing also on the question of proper working stress in concrete, is that of possible increase of strength with age. The strength given here is that at 28 days. With suitable conditions, concrete will gain strength for months and even years; and it may be expected that under good conditions of moisture and opportunities for the chemical action to continue, the strength of concrete, after several years, will be from 1.5 to 2 times as much as it is at 28 days; and here again is seen the difficulty of making specifications to cover all conditions. In the case of concrete roads, the concrete has shown a marked increase over the strength of the first few weeks. In a building, it is not certain that the concrete will retain sufficient moisture after the first few weeks to enable hardening to continue. The strength, therefore, may not be more than that existing at the end of 28 days, or at even an earlier age if it dries out quickly. The effect of moisture conditions is well illustrated by tests made for the Chicago, Burlington and Quincy Railroad over a period of ten years. The strength at 28 days ran very well; at 60 days, there was little gain in strength; at the end of a year, there was no further gain in strength; at 2, 3, 4, and 5 years, there was no gain in strength. Inquiry then made showed that the specimens had been stored in an ordinary room or shop, which was steam heated, and the concrete had evidently dried out at an early age. At the end of 6¼ years, half the remaining specimens were placed in water and the other half left in air; these were tested at the end of the seventh, eighth and tenth years. The specimens that had been put in water gained strength for the remaining three years in the way they would be expected to gain in the first three years if they had had sufficient moisture; those that remained in air did not gain strength. Other tests running over a number of years have shown the same result, that unless the moisture conditions are favorable, there will be no increase in strength beyond the early period. Whether or not an increase of strength will develop in a structure depends on the atmospheric and other conditions surrounding the concrete of the structure. It is well, therefore, to consider whether there will be much added strength beyond that attained at the end of 28 days, and the conclusion reached will have an important bearing on what value of the working stress should be adopted.

Another question enters into the problem, whether the concrete in the structure will have a greater strength or a less strength than laboratory specimens. Mr. Godfrey has frequently referred to test specimens made under ideal conditions. Sometimes poor concrete is put into structures, concrete undoubtedly poorer than that which would be made up in test

cylinders. In other cases, however, specimens cut from structures, floors, and columns of buildings, pavements, etc., have shown a higher strength than that given by laboratory methods. Whether this represents the situation generally is a question which should have consideration.

If this value of 800 lb. per sq. in. is high, and it would seem to be at or beyond the limit of proper allowance for concrete of this general quality, what is to be said of the additional 100 lb. per sq. in. of stress which is allowed at the section of negative moment. The concrete at the bottom of the beam next to a column or girder may sometimes be of better quality due to the pressure put on it, but again the difficulty of placing the concrete may be such that it will be poorer than the average. In the report of the first Joint Committee, 20% additional compressive stress was allowed at the negative section. The value was allowed under somewhat different conditions than given in this report. The allowable working stress at the section of positive moment was 650 lb. per sq. in. The positive bending moment was $\frac{1}{12\,w\,l^2}$ and the negative bending moment $\frac{1}{12\,w\,l^2}$, which together give 33% more moment than can occur as the sum of the moment at the end of the beam and in the middle; and the argument was then made that if the concrete at the negative section begins to fail, or gives too much, the effect is to throw a larger bending moment at the middle of the beam, and that larger bending moment can well be taken at the middle of the beam, because provision is made for a considerably larger amount, 33% larger, than would be given by the sum of the two moments. Here, the moment specified for the positive moment has been decreased to $\frac{1}{16\,w\,l^2}$ for one case. There is still a little excess, but altogether the conditions are such that 900 lb. per sq. in., seems too great a stress to be allowed at the section of negative moment.

The speaker would not agree entirely with Mr. McMillan that no account should be taken of the hooping in a reinforced concrete column. Surely an allowance may be made for it as a matter of safety; and a higher stress may be used, much nearer to what would be the limit of strength of the concrete, with a hooped column than with one in which hoops were not used. Why then should the stress allowed in the longitudinals be a percentage of the ultimate strength of the concrete? By the form of the column formula, it would seem that an effort has been made to take the hooping into consideration, for in the extreme case of a concrete having no strength a stress of 300 lb. per sq. in. would result. It will be helpful if the Committee will explain more fully the basis of the formula, in theory and by experiment.

It does not seem to the speaker that the shrinkage should take into consideration in the manner that has been proposed. As in the case of the action of spliced bars in columns, referred to by Mr. McMillan, the concrete and the steel may not act exactly in harmony. It would seem that some ultimate or critical load should be considered, a load beyond that considered as the working load. After all, working loads and working stresses are mere

conveniences. In taking up these fundamentals what will happen at some critical point should be considered; and when that is reached, the effect of shrinkage disappears, or disappears so nearly that it does not seem to need to be considered in such a way. If the explanation given is the basis of the formula, the form of the New York formula, or one similar in method to the New York formula, may be preferable.

The working stress proposed for sections of positive moment may be worth considering, although it is very high. The speaker thinks that 900 lb. per sq. in. for the section of negative moment is too great.

Elwyn E. Seelye,* M. Am. Soc. C. E.—The speaker feels that the theory of continuous beams as applied to reinforced concrete T-beams is unsound, because it pre-supposes the same section modulus in negative bending as for positive bending, whereas it is impractical to obtain this result.

A reinforced concrete beam should be considered as a practically restrained beam rather than a continuous beam and the amount of negative steel reduced to about 50% of the positive moment. The positive moment should be reduced somewhat to allow for this restrained action. The speaker has had a long experience in design and where he has used 50% of negative reinforcement, he has not been troubled with negative cracks. On the other hand, such a design is more practical because it does not cause a congestion of steel for the supports which otherwise happens, particularly at columns, where floor-beams may enter a column.

The speaker feels that this point is extremely important and although he knows that this matter has been discussed and apparently settled adversely to his opinion, he requests that the T-beam continuity be reconsidered.

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DETAILS OF CONSTRUCTION. DESIGN.

By Messrs. W. A. Slater, A. N. Talbot, R. C. R. Gautier, Clyde T. Morris, W. S. Thomson, F. W. Scheidenhelm, and A. W. Stephens.

W. A. Slater,* Assoc. M. Am. Soc. C. E.—The diagonal tension failures in reinforced concrete footings reported by Professor Talbot† occurred on sections analogous to those described in this specification. Slabs built to simulate the part of a flat slab around a column capital and tested at the University of Illinois under Professor Talbot's direction, failed in diagonal tension on a similar section. A flat slab tested by Professor W. K. Hatt, M. Am. Soc. C. E., for the Corrugated Bar Company, at Purdue University, failed‡ "with a feathering of the concrete on the drop at the edge of the column cap, followed by a diagonal tension failure in the drop around the head of the column".

In a flat slab tested at Worcester, Mass., a secondary failure by diagonal tension occurred. This is described in the words, "there were appearances of diagonal tension failure around Column B4, but it seems likely that this was a result or at most a secondary cause of failure"§. These two failures of flat slabs probably were not primarily diagonal tension failures, but they are the only diagonal tension failures for flat slabs known to the speaker. The failures in both instances occurred on sections analogous to the section outlined in the specifications as the critical section, and it seems that data are lacking, which would indicate that there is danger of diagonal tension failure on any other section.

It seems that the behavior of the flat slab is sufficiently like that of the column footing that the test results for the footings may be applied to the slabs. From the footing tests, Professor Talbot has concluded‖:

"As the diagonal tension cracks would begin at or above the longitudinal reinforcement, it seems a reasonable procedure to take as a measure of the diagonal tension stress the vertical shearing stress obtained by using the vertical sections located at a distance from the face of the pier equal to the depth of the steel reinforcement from the upper surface of the footing and to use as a length of section the four sides of the square base thus formed. * * * The procedure in getting a measure of the diagonal tension is analogous to that used in ordinary beams * * *."

Formula 38¶ represents an effort to put into the thickness formula all the requirements specified for the design of flat slabs, except the strength of the concrete. For instance, Sections 146 and 147 allow some latitude in the

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† "Reinforced Concrete Wall Footings and Column Footings", *Bulletin* 67, Univ. of Illinois Eng. Experiment Station, 1913.

‡ "Moment Coefficients for Flat Slab Design with Results of a Test", W. K. Hatt, *Proceedings* Am. Concrete Inst., Vol. 14 (1918), p. 164.

§ Talbot and Slater, "Tests of Reinforced Concrete Flat Slab Structures", Univ. of Illinois Eng. Experiment Station, *Bulletin 84* (1916).

‖ "Reinforced Concrete Wall Footings and Column Footings", Univ. of Illinois Eng. Experiment Station *Bulletin* 67, p. 103 (1913).

¶ *Proceedings*, Am. Soc. C. E., August, 1921, p. 98.

amount of moment to be used, and the introduction of the coefficient, R, into the formula makes the thickness depend on the value of R chosen. In the same manner, the introduction of the term, $\frac{l}{b_1}$, makes the thickness depend on the width of the dropped panel, which must resist the compressive stress due to negative moment. The thickness formula is based on consideration of 2 000-lb. concrete with the working stresses elsewhere specified.

Without a limitation as to the depth there is always a possibility of changing the critical section from the edge of the column capital to the edge of the dropped panel, that is, by making the dropped panel very heavy and very thick it may in effect become the column capital. Then, there will be moments at the edge of the dropped panel, which are not fully taken care of by the provisions that apply to the section at the edge of the column capital. The effort is to keep the dropped panel of such proportions that the critical section is not likely to occur at the edge of the dropped panel. It was considered that the most practical way of doing this, one that would not put too many complications into the design, was simply to set a particular limit for the thickness of the dropped panel.

Section 198 indicates that $0.45f'_c$ may be used as the "extreme fiber stress adjacent to supports of continuous beams". In preparing the sections on flat slabs, Section 198 was not interpreted as applying to flat slabs.

Another feature of Formula 38 that has not been mentioned is that the term $(1 - 1.44 \frac{c}{l})$ provides a thickening of the slab as the size of the column capital decreases. That term is intended to compensate for the concentration of moments along the edges of the panels (a concentration which takes place with decrease in the size of the column capital), and thus to keep the stress along the panel line at the edge of the capital at approximately a constant value for all sizes of column capital. This is merely a recognition that the larger the ratio of the span to the diameter of the column capital, the more danger there is of excessive deflection due to local high compression stresses.

The adoption of rather conservative slab thickness requirements was based on assumed compression and deflection requirements. It seems that the probability of a rich concrete flowing under compression and thus permitting an increased deflection would be greater than that for a lean concrete, and this may be a valid reason for keeping the requirements the same for concrete having a strength of 2 000 lb. per sq. in., or more. The Committee will give the matter further consideration.

Section 131, "Anchorage of Web Reinforcement," gives general provisions which are intended to guard against an unsatisfactory design, but possibly it should be more specific. In the tests made at Lehigh University on web strength of beams, in connection with the concrete-ship work of the Emergency Fleet Corporation, the anchorage of the web reinforcement was of different sorts, and among the types used were anchorages similar to those shown in Fig. 12. There was little difficulty with the anchorage of the bars under those conditions. With the largest sized bars used there were some

indications of slipping, and the provision given in the specifications as to the size of bar, one-fiftieth of the depth of the beam, is intended to meet the requirement that too large a bar shall not be used. Anchorage of the stirrups by means of a hook at the end developed the yield point stress in the web reinforcement though the yield point was around 60 000 lb. per sq. in.

The size of the longitudinal bars used in the tests referred to was in all cases $1\frac{1}{4}$ in. It does not seem likely that bars much larger than that would often be used. The length of the beam was not great, 9 ft. 6 in. between supports and 10 ft. 2 in. over all. In fact, the tests have been criticized for using beams which were so short. As far as the size of bars and length of span are concerned, the conditions were such as to aggravate the stresses. The tendency to increase bond stresses at any point is probably as great as under any conditions that could be arranged if one were trying to make them as bad as possible.

There was a variation in the spacing of the stirrups from about one-ninth up to once the depth of the beam. The series of tests in which the spacing of the stirrups was varied, is not so satisfactory in the uniformity of its results as the others; but it seems safe to state that even with a spacing as great as one-half the depth, the working stress recommended would be justified by the tests. It would not seem wise, however, generally to combine the highest allowable shearing stress with the greatest allowable spacing of the stirrups.

After the discussion of the subject of shear, it may appear that all the specifications are based on one series of tests, the results of which have not been published. A portion of the results from the concrete ship tests have been published, and there are published results of other tests in which very high shearing stresses have been developed and which will help to show the justification for the specifications here proposed. The following references indicate where the information may be found:

(1) R. Saliger, "Neue Versuche über den Schubwiderstand in Eisenbetonbalken". *Zeitschrift für Betonbau* (1913), Heft 8, p. 157; (1913), Heft 9, p. 187; (1914), Heft 1, p. 9.

E. Probst, "Vorlesungen über Eisenbeton" (1917), v. 1, p. 356.

Handbuch für Eisenbetonbau, 3d. ed., by F. von Emperger, p. 297.

(2) G. M. Braune and C. C. Myers, "Tests on Ten Reinforced Concrete T-Beams". *Concrete,* April, 1917.

(3) W. A. Slater, "Tests Show High Shears in Deep Reinforced Concrete Beams". *Engineering News-Record,* February 27th, 1919.

The possibility of using broken tiles must be admitted, also the possibility of chunks of wood getting into the concrete, and other unexpected things happening. Allowance is made for these things in the unit stresses that are permitted. If, however, there is a tile broken, what is to prevent the concrete from running in and filling up the place that the tile should take, unless, as has been suggested, paper is used in place of the missing tile. A specification, however, can hardly take into account the possibility of using paper instead of aggregate, except under the head of inspection.

The inspection should be rigid enough to take care of such things. This part of the specification should not rest solely on the negative basis that no

reason is apparent why a thing should not be done. There are data available, which show that tiles are effective in taking the compressive stress from the concrete near-by. To cite a case, a large tile and concrete slab was built at Waynesburg, Ohio, and tested by the U. S. Bureau of Standards, within the past two years. In that test, the deformation in the tiles was measured, the modulus of elasticity in the tiles was determined, and tests of control slabs of tile and concrete were also made, and it was found, in general, that the deformation in the tile was at least 70% of the deformation of the adjoining rib, and that taking into account the difference in modulus of elasticity of the concrete from that in the tile, the unit stresses in the tile in this case were approximately the same as the unit stresses in the concrete.

It seems safe to conclude that the same elements which made the flanges of the tile effective in compression, would make the webs of the tile, which are in contact with the concrete web, effective in shear. There is also some experimental basis for the belief that the webs of the tiles were effective in resisting shear. If, in the tests referred to, each of the ribs extending in the same direction within a panel is assumed to carry the same load to the supporting girders, the load so carried would cause a maximum shear of 375 lb. per sq. in. in each of the ribs of the square panels, if the tiles which were in contact with the concrete rib are assumed to be as effective as the concrete in resisting the shear. If the assistance from the tiles be neglected, the shearing stress in the concrete ribs would have to be 500 lb. per sq. in. However, the ribs along the center lines of the panels must have carried more load to the girders than those adjacent to them. Consequently, the maximum shear on the center ribs would be more than 500 lb. per sq. in., if assistance from the tiles is neglected. As there was no diagonal tension reinforcement in these webs, it seems certain that failure would have occurred before reaching so high a load, if the clay tiles had not assisted very considerably in resisting the shearing stresses. The speaker's opinion is that for certain cases all the section of the tile might safely be considered effective in shear.

A Government building in Washington, D. C., in which clay tile was used, was tested and the results were satisfactory, even though the moment coefficients used seem to have been much lower than can be justified by analytical treatment.

There are certain forms of construction in which the flange of the tile is not below the neutral axis. The form of construction referred to, has no concrete over the top of the tile. The depth of the tile is the same as the total depth of the slab.

A. N. Talbot,* Past-President, Am. Soc. C. E.—The results of tests, published in *Bulletins* of the University of Illinois, show that the reduction in bond resistance was very definite and the phenomenon connected with the failure of the footings by slipping of the bar was striking. That is the weak point in any footing that is made with two-way or four-way reinforcement. The speaker thinks 25%, as given in Section 143, is not sufficient reduction.

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In ordinary beams, cracks, whether visible or not, may be expected to form, at loads below those giving working stresses, and these will generally not be injurious. With a footing, the case is different; the crack across one set of bars runs lengthwise of a bar in the other direction, and thus the bond resistance is reduced appreciably. It may not always be necessary to anchor the bars at their ends. This is the best solution. It is a question that should have full consideration. The tests referred to are the only tests of the kind of which the speaker has knowledge. It may be said that failures in footings may occur without any knowledge of it. Some of the settlements may be due to failures in footings.

Although it is assumed that the reaction of the soil is uniform over the footing, in compressible soils, at least, more upward pressure is transmitted immediately under the column and less at the edges of the footing. It seems to the speaker that the provision to reduce the allowable bond stress in cases of two-way and four-way reinforcement, is a step in advance.

The speaker has been told that the Committee on Bridge Specifications of the Society is to deal with reinforced concrete bridges, which is quite an important field. It would appear that the Committee could well give attention to some of the salient features and precautions for a variety of reinforced concrete construction, as, for example, frames, to note, not in detail, the matters that may well be provided against, or, in the case of arches or bridges, the matters that should be provided for. The speaker believes that it would be valuable to many designers if suggestions could be given in regard to the construction of different types of reservoirs, and something applicable to piers and abutments. It would be difficult to make complete specifications for these. The report of the Committee covers the general specifications for buildings; parts of it, however, are applicable to all these other structures.

The former Joint Committee followed the practice of giving precautions for certain details in terms of building construction, positive moment, and negative moment, etc. In the case of a bridge there are places where these precautions would not apply and where others would be needed; although the principles are the same, the values of moment to be provided for will differ. In reservoirs and in reservoir foundations, the case would be still different. This is indefinite, but, at least, it will suggest that these other structures should be taken into account and some notice taken of what are applicable only to buildings.

The problem before the Joint Committee is difficult. Perhaps it may be well to segregate those parts of the specifications that apply only to reinforced concrete buildings. The former Joint Committee report attempted to prescribe good practice in the use of concrete and reinforced concrete. The fundamental thought in this specification seems to be that it can be used as a whole or in part, the engineer supplying the additional engineering needed for the application to the structure in question. Can a general specification be written with provisions for the peculiar requirements, for instance, in the arch or in the bridge in the way that the report deals with buildings? What the speaker had in mind was whether the Committee could look into several fields and find

if there are not features of special construction that may well be included in the specifications, and not to write specifications for this structure or that form of construction.

R. C. R. Gautier,* Assoc. M. Am. Soc. C. E.—The speaker has noticed in the tentative specifications that it is proposed to allow, in floors made up of concrete and hollow tile, taking half the thickness of the web in shear. He has seen, very often on the job, broken tiles which nevertheless were used, the broken corner or side being filled up with a piece of paper to replace the missing web, and, under the circumstances, it seems somewhat doubtful to allow the use of the tile web to resist shear. However, the speaker is convinced that, with proper inspection, such practice would not take place, and he is of the opinion that, in such a case, it is perfectly legitimate to use the tile web to help in resisting the shear, and also the upper flange of the tile to help in resisting the compressive stresses. He knows of some systems in which no concrete whatsoever is used as a topping for the tile, the entire compression being taken by the concrete joist which is very narrow, and the flange of the tile. Such types of construction appear to be successful, and the speaker does not see why this should not be accepted as good practice.

Clyde T. Morris,† M. Am. Soc. C. E.—The Committee has gone further than would seem necessary in specifying moments to use in design for continuous slabs and beams and rigid building frames. There are so many local conditions affecting every case that the ideal conditions of the specifications are seldom realized. In furnishing data of this kind without a definite statement of the conditions, there is danger, since it probably will be used in an improper manner by inexperienced designers.

These moments are so vitally affected by the relative span lengths, column heights, and stiffnesses, that they should be calculated by an experienced designer in every case.

The investigations and report of the Committee should include the fundamentals of concrete bridge and road design and construction if it is not to be limited to a building specification and is to be what the title implies. Unit stresses for bridges of various types, treatment of expansion and contraction, shrinkage, etc., should be included.

Referring to Section 134 on tile in combination tile and concrete construction, the point brought out was that the Committee meant to use only half of the adjacent webs as shear material. In one or two cases, where the speaker has investigated the safe carrying capacity of flooring in place, he has taken account, in an eight-plus-two floor, of the top web of the tile as helping out the thickness of the flange of the T.

W. S. Thomson,‡ M. Am. Soc. C. E.—Relative to the discussion on the design of combination clay tile and concrete rib floors, the speaker believes that it is quite proper to consider the width of the rib as equal to the width of the concrete section plus one-half the thickness of the tile wall on either side of the concrete rib, in so far as shearing stress is concerned.

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† Prof. of Structural Eng., Ohio State Univ., Columbus, Ohio.

‡ Chf. Engr., Corrugated Bar Co., Inc., Buffalo, N. Y.

In the construction described by Professor Morris, this same idea was applied in the case of the top wall of the tile and its thickness added to that of the concrete cover to provide increased area for the resistance of the compressive stress. This practice, however, might be considered questionable, as a joint occurs every 12 in. between the tile blocks and unless the ends of the tile were in perfect bearing at all points, which is seldom the case, it is difficult to conceive of successfully transferring stress across these joints until considerable deformation had taken place.

F. W. Scheidenhelm,* M. Am. Soc. C. E.—A number of additional subjects for the proposed specifications have been suggested. The speaker can suggest still another, he refers to the subject of dams. This subject is of interest to the speaker, and he would be glad to have the Committee go into it as thoroughly as has been done with the subject of reinforced concrete building construction.

The specifications should not cover less than reinforced concrete building construction. A report containing, not merely provisions of general application, but also provisions pertaining specifically to building construction, would have great value for the designer of other structures, in that, by comparison he can determine what practice to adopt. There would seem to be no valid objection to including retaining walls with buildings, particularly since the present specification already covers retaining walls.

A. W. Stephens,† Assoc. M. Am. Soc. C. E.—When any paragraph in the specification does not apply to all types of reinforced concrete structures, this fact should be definitely stated and the application of the clause clearly defined.

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GENERAL DISCUSSION

By Messrs. L. J. Towne, J. E. Torrey, E. J. Beugler, A. N. Talbot, H. C. Turner, G. Harrisson, John W. Ferguson, George H. Pegram, W. H. Rose, Elwyn E. Seelye, Sullivan W. Jones, George L. Lucas, Herbert W. Goddard, L. E. Kern, W. N. Patten, and D. H. Dixon.

L. J. Towne,* Assoc. M. Am. Soc. C. E. (by letter).†—The following comments are submitted on those parts of the report relating to construction practice.

General.—The report is, in the writer's opinion, open to the following general criticisms:

The title "Specifications for Concrete and Reinforced Concrete", is unfortunate, and the form of the old report, namely, a set of fundamental principles representing recommended practice for the guidance of the engineer, is much to be preferred.

The term, "Standard Specification", implies a document which can be incorporated more or less verbatim in working specifications, and which includes all the detailed instructions necessary for the proper execution of the work. The concrete industry, however, is so infinitely varied that the attempt to lay down a set of specific rules to cover the multitude of conditions which arise in practice is likely to result in extended controversy, and, if finally adopted, in a weakened authority of the entire report. Whereas, if the report were to be considered as representing the best thought on fundamental principles, leaving the details to be worked out by the individual engineer, it would not only be easier to secure agreement on the various provisions included in the report, but, as adopted, the report would tend to carry greater authority.

For example, many engineers would oppose, at the present time, the inclusion of the provision for automatic measurement of mixing water as a standard specification, who would agree that such automatic measurement was correct in principle and desirable of accomplishment as rapidly as the practical difficulties connected with it could be overcome. In the writer's mind, a standard specification is a record of what has already come to be accepted as standard practice. If this is true, certainly many of the paragraphs of this report may better be considered as sign posts pointing the way to the improvement and development of the art of concrete construction. As such, it has great value for the profession, but there is surely a clear distinction between such a set of principles and a standard specification.

Proportioning Concrete for Strength.—The proposal to proportion concrete to secure definite strength based on laboratory tests of compression cylinders represents a distinct advance in the art, which will tend to economy of materials and a better class of concrete construction. It should receive therefore the thoughtful consideration of every engineer. One can agree with this principle,

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† Received by the Secretary, December 8th, 1921.

however, and, at the same time, hold grave doubts as to whether the time has yet come when concrete can be purchased on the basis of strength in the same way that structural steel is now purchased.

It is true that thousands of laboratory tests have apparently established with reasonable accuracy the relation between the component parts of the concrete, including water, and the resulting strength of the specimen. However, the question of the relation between the strength of specimens made in the field and the strength of laboratory specimens from the same aggregates has had comparatively little attention. The writer had occasion recently to compare a series of field tests of compression cylinders made under working conditions, in which the water content and "slump" had been carefully recorded, with the predicted values in Table 4 of the report of the Joint Committee. The results showed no relation whatever between the actual and the predicted strength. Probably, if all the variable factors were known, including the personal equation of the man making the specimens, the discrepancies might be satisfactorily explained, but the experience brought forcibly to mind the fact that there is much ground to be covered before one may confidently predetermine the strength of concrete under conditions existing in the field.

It is the definite policy of the firm, with which the writer is connected, to make regular compression tests of field specimens on all important work. All engineers should be encouraged to make such tests a standard practice on important work, in order that data may be accumulated on this subject and in order that field engineers, superintendents, and foremen may be educated to the importance of careful proportioning and mixing. At present, it does not seem that the Joint Committee report should go further than to outline a method by which engineers may, if they desire, leave the final proportioning of the concrete subject to the results of tests of field-made specimens.

It seems especially unwise in the present state of the art to fix the responsibility for securing concrete of a definite strength on the contractor. The responsibility for determining the proper proportions of cement aggregate and water should rest on the engineer. When the contractor has followed the engineer's directions in this regard, as well as his specification for time of mixing and workmanship in general, he has gone as far as he can be expected to go, and should not be held responsible for the strength of the concrete, except where defective work can be traced to his failure to conform to the engineer's specifications for either materials or workmanship. Any other policy will result in endless confusion in the enforcement of the specification and will work to the disadvantage of the honest contractor and in favor of the less scrupulous contractor who is willing to take a long chance.

The following are a few detailed criticisms and suggestions for individual Sections:

Chapter III.—Quality of Concrete.—It is suggested that Sections 3 and 4 be omitted and that the quality of the concrete be specified under "proportioning" as noted hereafter.

A separate chapter should be devoted to Section 5, "Tests of Field Specimens". The American Society for Testing Material specification referred to, deals only with the technique of making, storing, and testing specimens.

Additional Sections should be inserted to cover such items as the following:

1.—Provision for preliminary tests prior to starting work, including methods of securing fair samples of available fine and coarse aggregates.

2.—Number of tests to be made in terms of quantities of concrete poured.

3.—Fixing responsibility between the engineer and contractor for the making and curing of specimens and for the cost of testing.

Chapter IV.—Aggregates.—A clause should be inserted providing that the contractor shall submit, to the engineer for his approval, samples of the fine and coarse aggregate to be used on the work before the orders for material are placed.

Chapter V.—Section 27.—It is suggested that the word "preferably" be inserted in the last sentence so as to read "The water shall preferably be measured by an automatic device", etc.

Chapter V.—Section 28.—Table 11 is suggested as a substitute for Section 28, in cases where the engineer desires to specify the strength of the concrete. The proportion of cement, water, and aggregate, and the desired strength shall be as given in Table 11.

TABLE 11.

Class.	Portland cement.	Fine aggregate.	Coarse aggregate.	Consistency by slump test.	Desired strength at 28 days.
A	1	....	....	....	....
B	1	....	....	....	....
C	1	....	....	....	....
D	1	....	....	....	....

The quantity of water used shall be such as to produce concrete of the consistency specified in Table 11, as determined by tests. After the engineer has approved the fine and coarse aggregate to be used for the work, and before any concrete is poured, he will advise the contractor whether any changes are desired in the proportions given in Table 11 in order to obtain the desired strength. The engineer may also at any time during the progress of the work make such changes in the proportions of water, fine and coarse aggregate as are necessary to obtain concrete of the desired strength as determined by tests. Where such change involves an increase or a decrease in the cost of the concrete materials, the price for the work shall be adjusted as provided in the contract.

Chapter IX.—Section 79.—In view of the fact that water-proofing compounds, including hydrated lime, have been used with success in many cases, and the fact that membrane water-proofings have often failed to give adequate protection, it seems to the writer unfair to rule out entirely either type of water-proofing.

J. E. Torrey,* M. Am. Soc. C. E. (by letter).†—There are a few points in connection with the proposed Standard Specification, to which the writer would like to call attention.

Section 52, fourth line, specifies that form lumber "shall be free from loose knots or other defects". A strict interpretation of this wording would require the use of a "clear" grade of lumber. If this were modified to read, "free from loose knots or other serious surface defects", it would result in obtaining a grade of lumber suitable for the purpose.

In connection with the specification for Forms (Chapter VII), the writer believes it will be desirable, at least, to make some mention of the use of metal forms. These have reached a fairly satisfactory stage of development for use for circular columns, tanks, and silos, and although the design and detail of metal forms for walls, beams, and slabs has not, perhaps, reached a parity with the practice in wooden forms, considerable progress is being made. In view of the increasing shortage in the lumber supply, any means which would tend to decrease the wastage of lumber, incident to the building of concrete structures, should be encouraged. If, after specifying wood forms in considerable detail, no mention is made of metal forms, there will undoubtedly be instances where their use will not be permitted on the grounds that they are (by implication) not permitted by the Specification proposed by the Joint Committee.

A simple statement, to the effect that if metal forms are used, they shall be designed to carry adequately the loads and constructed and fastened so as to give the desired results of surface and line (as specified for the wooden forms), should be all that is necessary.

In Section 54, it is stated that, "wire ties will be permitted only on light and unimportant work". "Light and unimportant" is not a definite classification and interpretations of it will probably vary greatly. In the writer's opinion, the question of whether bolts or wire ties should be used is merely one of economic design, as in every case the section and spacing of the ties will be determined by the loads to be carried. Wire ties should not be prohibited on account of surface discolorations, as they can be easily kept back at least 1 in. from the face of the concrete.

In Section 187, the writer would suggest that the mention of metal bases for the longitudinal reinforcement be omitted and that dowels be used as specified in Method *B*. Metal bases for the longitudinal reinforcement would undoubtedly be efficient if the ends of the rods and the top of the plates were milled true and the rods placed so that they were in full bearing. The metal bearing-plate used in conjunction with the ordinary sheared rod will nearly always result in an undesirable increase of stress in the concrete near the bottom of the column.

This is due to the fact that the vertical rods in almost every case will have bearing on the base plate only at a single point and under load there will be a tendency for the metal to flow until an area of bearing sufficient to cause equilibrium is reached. When this occurs, the tendency to slip in the rods is resisted by the bond, and the stress in the steel is transferred to the concrete,

* Chf. Engr., John W. Ferguson Co., Paterson, N. J.

† Received by the Secretary, December 17th, 1921.

and with the sheared rods generally used, it is only occasionally that one will be found with the end sufficiently true to develop the required bearing. The writer has no record of any extensive series of measurements to determine the amount of irregularity in the sheared ends of reinforcing rods, but measurements of eight samples of 1-in. and 1⅛-in. square rods which were being forwarded for test, showed all the ends out of square, varying from $\frac{3}{32}$ in. to $\frac{13}{32}$ in., the average being about $\frac{1}{4}$ in., and this, he believes, will be found to be fairly representative of the sheared rods used for reinforcing.

Where the condition of the ends of the rods precludes their developing the required bearing the transfer of stress will occur over the effective bond length and will be cumulative, the maximum stress in the concrete being reached at the bottom of the column and with normal load and design, will largely exceed the allowable working stress. By using dowels the over-stressing of the concrete at the base of the column will be avoided, the condition being the same as for a normal column splice.

Another disadvantage of the ordinary metal base plate is the fact that the lower ends of the column rods are not rigidly held in position and are likely to become displaced during concreting. The dowels can be set accurately in the proper location without difficulty and will automatically fix the location for the column steel and prevent its being displaced.

It will also be found in the majority of cases that a satisfactory metal base plate will be more expensive than the dowels, and the writer has yet to find an instance where dowels could not have been used to advantage.

The use of the metal base plate for columns dates back to the earliest days of reinforced concrete construction and was necessary, at that time, to comply with the requirements of the various municipal building codes which differentiated between the material in the superstructure and in the foundations. Even to-day, in the codes of some of the smaller towns, the limit of compression for concrete foundations will be found to be 15 tons per sq. ft., whereas for common brick laid in cement mortar 18 tons per sq. ft. is permitted. To what extent the persistence in the use of the metal base may be due to habit induced by long usage, is purely a matter of conjecture, but it is probable that this will go far toward explaining it.

It is the writer's belief, based on experiences with the report of the former Joint Committee, that regardless of whether the proposed Standard Specification is intended to be used as a "guide for engineers" or as "recommended practice", it will, in many cases, be used as an absolute standard and if it contains many points that are not entirely clear, clauses in which the wording permits of more than one interpretation, or alternate methods of procedure are allowed, considerable trouble may result from its interpretation by persons not fully capable of doing so, along broad lines.

E. J. Beugler,* M. Am. Soc. C. E. (by letter).†—The Joint Committee has done splendid work in presenting the Tentative Specifications. That all engineers and constructors give careful consideration to them is neces-

* Vice-Pres., The Foundation Co., New York City.

† Received by the Secretary, December 7th, 1921.

sary in order that such methods be eliminated, that would not, under average working conditions, accomplish the desired results as to strength and integrity of design, and, furthermore, that any requirements be omitted or modified that might delay or add to the expense of construction, without securing commensurate results.

Section 12.—This section seems to be somewhat involved and the first part is made void by the qualification in the latter part. There should be a limit to the organic impurities in sand which could be fixed as desirable, but the specifications should permit the use of local materials as long as the requisite strength is secured. This is particularly vital in connection with foreign work, where the available materials may not ordinarily meet with American specifications for concrete aggregates. The specifications as finally adopted should provide for such contingencies, under the control of the engineer.

Section 19.—It is suggested that fresh water should be specified unless otherwise permitted by the engineer.

Section 28.—The first two alternative methods of proportioning set forth in this section seem to place the responsibility as to proportioning materials on the constructor rather than on the designing engineer. Heretofore, it has generally been the engineer's province to specify materials, form, and combinations for various parts of a structure. In the specifications for steel structures, definite strength of materials is called for, which differs, however, from concrete work in which more or less variable materials are combined on the work and not in the mill as a definite manufactured product.

To specify proportions of cement, water, and aggregate to produce certain strengths of concrete and then to give the proportion of cement, fine aggregate, and coarse aggregate, and, further, to require that the water shall produce concrete of a certain consistency, seems to be somewhat inconsistent. It would appear better and less complicated to specify at once the proportions of cement and aggregates for the guidance of the constructor after the engineer has determined from an examination of the available material what these proportions should be. Tests made from time to time would confirm the engineer's judgment or indicate what changes should be made in the proportions. It is suggested that Section 28 be worded as follows:

"*Proportions.*—The proportions shall be 1 part of Portland cement, ... 2 parts of fine aggregates, and .... 2 parts of coarse aggregate. The proportions of materials shall be selected by the engineer from Table 4 to conform to the characteristics of the best available materials. In case the grading of the supply of available aggregate varies from that on which the proportions were based, such aggregate may be used, provided the new proportions, as determined by the engineer, are such as to produce concrete of the required strength and quality."

It is also suggested that it would be well to go one step farther and specify the quantity of water to be used. A relatively small variation in the quantity of water has an appreciable effect on the strength of concrete, and the amount of moisture in the sand and on the stone may vary considerably. The latter element, however, can be provided for and considered as a part of the total water requirement, and can be readily fixed by the engineer on the job from time to time to give the required total.

Table 4 which gives the proportions for concrete having certain compressive strengths at 28 days, will be helpful to engineers in determining the effect of various sizes of fine and coarse aggregates and the consistency depending on the quantity of water used. The somewhat recently adopted "slump" test seems to have been overworked, and it would add to the Committee's report to supplement the slump characteristics by the proportion by volume of water used to give the indicated "slump" with standard dry aggregates. Allowance can then be made for the quantity of water in the sand on the aggregates and other contingencies.

These comments have been made from the standpoint of both the engineer and the constructor, and with a view to securing proper strength in the structure, combined with expedition on matters of construction. Full consideration has been given to ordinary construction conditions over a wide range of territory.

Section 35.—It is suggested that water be included and that the section read "débris and water shall be removed".

Section 41.—It is suggested that salt, chemicals, etc., shall not be used to prevent freezing or accelerating the setting unless authorized by the engineer.

Section 46.—Hand mixing should be permitted if authorized by the engineer. It frequently happens that the use of a mixing machine is not justified.

Section 51.—This section should be made more specific and should state how laitance is to be removed. "All scum or laitance accumulating on top of concrete placed under water where concreting has stopped, shall be entirely removed before any further concrete is placed and the surface thoroughly cleaned."

Section 65.—Future bonding should indicate how reinforcement bars may be protected from corrosion.

Section 69.—This section should be worded so that the engineer will be responsible for indicating the location of all construction joints.

Section 79.—This section should permit, on the approval of the engineer, integral compounds, and it might be well to segregate water-proofing into at least two classes: First, when it is more in the nature of damp-proofing; and, second, when there is more or less head of water on the work.

Section 84.—This section states that "sea water shall not be allowed to come in contact with the concrete until it has hardened for at least four days". For concrete deposited under sea water, it is not quite clear how this is to be accomplished.

A. N. Talbot,* Past-President, Am. Soc. C. E.—The speaker would suggest the consideration of provisions to increase the life of outdoor structures. Probably all engineers have been struck with the deterioration in many outdoor concrete structures. Possibly they have been too content with the idea that concrete is permanent under any and all conditions. Perhaps the Committee would be willing to undertake the specifying of requirements that should be made for the protection of the outside of structures from the elements; this would be worth while. Engineers add 1 in. or 2 in. for

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fire protection. Is it necessary, under some conditions in reinforced concrete structures, especially where the section is thin, to have a protective coating? If it is, should that protective coating be ordinary concrete, and how should it be applied? Or, should some other means be taken to protect the concrete and reinforcement from the action of the elements? That much of the deterioration in concrete structures is due to poor concrete, poorly placed or poorly proportioned, or poor materials is true. However, there are cases where fairly well proportioned concrete has suffered from weathering conditions in such a manner as to show relatively short life. Part of this trouble is due, evidently, to the changes in volume that have occurred with repeated variations in the moisture content, as well as with repeated temperature changes. An examination of structures will show, not only checks, but frequently cracks that may have come from such sources. Should there not be, then, a provision for the purpose of increasing the life of such structures? How may that be undertaken? That is a question which it seems to the speaker, the Committee might well consider.

Reference has been made to the desirability of having specifications for types of structures other than buildings. It is appreciated that the Committee cannot consider in detail many types of structure; and yet there are certain salient matters of design in the several types of structures on which there is likely to be a difference of opinion, or which may be overlooked by a designer who has not had experience in the particular type of structure. It would be well in some way to call attention to the requirements needed in such matters.

Reference has also been made several times, to the effect that the adoption of new or changed specifications and requirements will have on the cost of construction. The speaker has heard that a change in the way of increasing requirements took value out of existing buildings. There seems to be a view, in some quarters, that it is all right to have re-adjustment, but it must always be a re-adjustment downward; so this is not only an important question, but it is a rather delicate question. All appreciate the position of the Committee and the difficulties it encounters when an attempt is made to change bending moments, or to change the working stress, particularly if that working stress is decreased. It must be recognized that there is an intimate relation between the cost of structures and their design; this must always be taken into consideration. There are complications, however; once a certain regulation is provided, it is difficult to make a change. If New York City establishes working stresses for columns, that seem to be extreme; if, when the flat slab was first constructed, a low factor was used in certain structures, a low moment coefficient, and extremely thin slabs; if, in Chicago, the establishment of the flat slab regulation gave requirements which in any respect were low; or if, in San Francisco or some other city, tentative regulations were made on some other aspect of building construction, the feeling seems to exist that each one of these requirements must continue to govern any regulation that may be made.

The speaker is citing this to show the difficulty of introducing a requirement that is more exacting than existing requirements; if a change is to be

made from existing requirements, some radical objection must be made. The Committee needs the support of engineers in making changes upward as well as downward, as it may see fit; and after it is considered whether there is adequate margin between the working stresses and the strength of the structure, the matter of whether the cost has been increased should not be a large factor in deciding on what to do. Cost is an element of importance, but it is of a relatively temporary nature. In a few years the cost of the buildings already constructed will be forgotten.

H. C. Turner,* Assoc. M. Am. Soc. C. E.—The speaker is vitally interested in certain phases of the report of the Joint Committee: First, as to the preparation of a standard specification as against recommended practice; second, as to the establishment of a new policy in a specification for concrete, by strength instead of by specified definite quantities of materials as has been the custom in the past; and, third, the problem of whether the work by the Committee is in the direction of greater economy in the construction of concrete structures, generally.

First, it is difficult to write a standard specification that can deal fairly and justly with the variety of structures in the field of reinforced concrete or concrete, which presents a strong argument for recommended current practice, instead of a definite specification. The speaker's inclination would be in favor of recording what might be considered the best practice based on experience.

The second proposition, of whether progress in research has been sufficient to justify the acceptance of certain alternates which would bring about the specifying of concrete in terms of the strength as measured by cylinders at 28 days. It has been the practice for years for the engineer to say to the contractor that he shall furnish certain definite quantities of cement and aggregate of prescribed quality, mix them in a certain definite way, and deposit the concrete in work. Having done so, the contractor could assume that he had performed his contract and would receive the consideration prescribed.

It does not seem that sufficient progress has been made as yet to justify such a radical departure from past practice. The reinforced concrete industry has progressed rapidly during the past twenty years, and the character of the work has improved; and as far as the speaker's experience goes there is nothing in the design or construction of reinforced concrete buildings that makes it necessary, at this time, to depart from established practice and to accept a plan that would lead to chaotic conditions in the industry.

All engineers and contractors who have made tests, realize that wide variations are obtained in the strength of cylinders. This may be due to a lack of control in assembling the materials, their selection, and mixing, or, also, to the variation of the test cylinders themselves. From the speaker's experience this measure is too variable; and to adopt the plan of requiring the contractor to furnish concrete of a definite strength, as measured by cylinders at 28 days, is to bring about a condition that will create discussions and dif-

* Pres., Turner Constr. Co., New York City.

ficulties between the engineer and the owner and the engineer and the contractor.

Before such a plan could be recommended, it would be necessary to devise some method of determining the quality of the concrete as it leaves the mixer, so that the contractor, when he had assembled his materials and mixed them, could require the engineer to state that the work was or was not in accordance with the contract. If the decision is left for 28 days, the material has been covered and cannot be removed. This situation would call for financial adjustment as between the contractor and the owner not due necessarily to defective work and not that the building might not be ample for the purpose intended, but because the cylinders which are used for the purpose of measuring the work, are uncertain in themselves.

On the third proposition as to the effect on cost, it seems that anything which may be done at this time, in the preparation of specifications or recommended practice, should be to effect a reduction in the cost of concrete. The speaker recently talked with the Superintendent of Buildings of New York City as to his observation of the working of the New York Code with respect to reinforced concrete. So far as he could recall, without making a study of records, he felt that the Code has been successful in its operation and that he did not know of any criticism which had come from architects or the public because of any deficiency in the requirements. There is an ample factor of safety, perhaps greater than is required, at least it is greater than is required of other forms of construction in competition with reinforced concrete.

Twenty years ago, when tests were made on concrete cubes, engineers obtained on the average at least 2 000 lb. for 1:2:4 concrete. For many years, the concrete work done in this territory was based on tests of 4-in. or 6-in. cubes combined with load tests on beams and slabs. The New York Code adopted practically a 1 : 2 : 4 concrete with working stresses based on 2 000-lb. concrete. The buildings as constructed and tested have demonstrated their safety.

The primary thought, probably, which underlies the recommendations of the alternates, is to require some method to be developed to control the water content. It is not necessary to write a law to secure this. Contractors are ready to adopt any method that will improve the quality of the work; and, in order to secure the benefit of better control of the water content, it is only necessary to broaden education on the subject.

G. Harrisson,* Assoc. M. Am. Soc. C. E.—It has been said that certain phases of this specification present quite a shock to present practice. It is quite possible that the present condition of building ordinances and the time that will be required for the new facts to be absorbed, may be depended on to act as a most effective shock absorber.

The design and construction of chimneys has not been mentioned and might be considered to advantage. This work is being done almost exclusively by contractors who have different ideas and theories on the subject, some of

* Cons. Engr., New York City.

which are unsatisfactory. The standardization of design and practice with regard to chimneys might well be incorporated herein.

John W. Ferguson,* M. Am. Soc. C. E.—Some of the requirements under the proposed standard specifications for reinforced concrete would be almost impracticable in every-day operation and, if strictly followed, would materially increase the cost, and would tend to drive out of the field many of the best constructing firms in the reinforced concrete industry, because of their unwillingness to place themselves in a position where they might so easily become involved in the many complications possible under this specification, namely, lawsuits, delayed payments, and other difficulties. It is certainly neither just nor ethical for the engineer to cause the contractor to assume the responsibility for the strength of a material when the proportioning of the ingredients, the mixing and placing, have been definitely fixed by the engineer's specification.

The point has been raised as to how a specification of such technicality might be handled by supervising engineers in charge of work. On account of the arbitrary character and severity of some of its provisions, the interpretations will vary widely according to the personality of the supervising engineer. Whenever specifications are too rigidly drawn, there is a possibility that their enforcement will not be uniform, and bidders will calculate on the basis of what their previous experience with any particular engineer would indicate that he would require, rather than on the specification itself. This places bidders whose estimates are based strictly on the specifications, at a great disadvantage.

This specification has been referred to as being for the guidance of engineers in making their designs and specifications for specific work, and it undoubtedly would be used in that way by those who are thoroughly familiar with reinforced concrete construction.

There are, however, many architects and engineers who do not specialize in reinforced concrete construction, who might use this specification in its entirety without fully comprehending all its requirements, and under such conditions it would be subject to misuse and abuse. This is more apt to be true in connection with comparatively small jobs; the aggregate of these, however, is usually considerably in excess of the large jobs. A specification emanating from or endorsed by the Society would undoubtedly be taken as a standard and used without variation by those not fully familiar with the intent.

Taking the proposed specification as it stands, the responsibility is placed on the contractor for the strength of the structure based on tests of specimens made twenty-eight days after the concrete was poured in place. Any slight defect in the test specimen, or a variation in the handling or storing of the specimen, in fact, the normal irregularity of results of compression tests, might indicate the strength of the specimen to be less than that required, but the concrete in the structure itself might be fully up to the specifications. Cases of this sort would result in serious complications for all parties

* Engr. and Bldg. Contr., Paterson, N. J.

involved. After a few experiences of this kind, the contractor would cease bidding for work under these specifications, as he would not be willing to take the risks involved of lawsuits, disputes, compromises, and contentions, in order to do a piece of work on a close margin.

George H. Pegram,* Past-President, Am. Soc. C. E.—The speaker's attention has been drawn to this matter of Alternate 2 of Section 28. It seems to him that it is both unethical and inequitable; but aside from that, he cannot see how it can be complied with in securing results. It is the desire to secure the best contractors. The contractor who bids on a specification that contains uncertainties, if he is a good contractor, will usually add some percentage to his bid, in order to cover those uncertainties; but there are always those contractors who are ready to take risks, and it may be that after this specification is tried, it will be found so difficult in application that the engineer may get in the habit of giving the contractors the benefit of the doubt, which they should do, and it may lead to the reverse of what is intended. It seems a great deal like asking the contractor to guarantee that the stress in the bottom chord eye-bars of a bridge shall not exceed a certain amount. The disputes that may arise later will cause so much trouble, that it will be much better to retain the custom that seems to prevail generally in specifications for construction, and specify definitely what the different materials are required to be, and also how they shall be incorporated.

A suggestion that comes to mind from this proposed specification, is this, that it might be well in the progress of the construction of a structure to take samples as the work progresses, and to test them as proposed, and in that way to educate engineers as to what may be expected. After that has been done for some time, sufficient data may be obtained on which to base some such specification.

W. H. Rose,† Assoc. M. Am. Soc. C. E.—The speaker thinks that the Tentative Specifications are especially valuable in calling to the attention of engineers, the importance of recent investigations and research on the grading of aggregates, and on the quantity of water to be used, and in placing in a practical form, in Table 4, the results of those researches and experiments.

The section of the specification that seems to be most in controversy, Section 28, with its three alternatives, is very interesting, and the speaker agrees in general with those who have spoken with regard to the inequity, and, to a certain extent, the impracticability of Alternatives 1 and 2. The speaker thinks that Alternative 3 gives a practicable method of using the information in regard to the quantity of water and the grading of the aggregate that is contained in Table 4.

The speaker looks on Alternative 3 of Section 28, as one for the general guidance of engineers, and one that can be amplified in considerable detail in the writing of a specification for a particular job. If Alternative 3 was to be used for a reinforced concrete building in the City of New York, one might specify more particularly provisions like the following:

* Chf. Engr., Interborough Rapid Transit Co., and Rapid Transit Subway Constr. Co., New York City.

† Dist. Mgr., Lockwood, Greene & Co., New York City.

"The design of this structure is based on the use of concrete of such quality as to give a compression strength of 1 500 lb. per sq. in. when tested under the rules of the American Society for Testing Materials. It shall be mixed in the proportion of 1 : 2 : 4 and no more water used than that which will give a slump test of 6 to 7 in. In case the mechanical analysis of the coarse and fine aggregate is such that Table 4 of Standard Specifications of the American Society of Civil Engineers shows less than the compressive strength specified, the contractor shall add sufficient cement to produce the required strength, or use aggregates that will produce the required strength."

There would be very few cases in which this specification, applied in the Metropolitan District, would require any alteration in the proportions stated. If the work is being performed in some locality in which the aggregate is not so well known, after the contractor knows the strength on which the design is based, after he has been given the proportions and the quantity of water, he can, from Table 4, see what the mechanical analysis of the aggregate should be to produce at least the designed strength. The particular quality of the fine and coarse aggregate with regard to cleanliness, hardness, strength, durability, etc., are covered in the specification for the aggregate, just as the qualities of the cement are covered. If the contractor finds in some locality in which he does not know by experience what he may expect from the aggregate, that he is obtaining a strength too low with an aggregate that in quality is still acceptable, he knows that more cement must be used, or, by screening or otherwise, he must obtain aggregates so graded that, with the same quality of cement, the desired strength will be produced. In the majority of cases the solution of this problem will be to use more cement, as to do so will usually be easier and cheaper than to change the aggregate. The contractor will have as the only variable the quantity of cement required, and that is the element with which he is best able to deal. If more cement is needed, he knows how much he is going to pay for the additional volume. If it is insisted that another aggregate be secured, he does not know how much he will have to pay for sand, gravel, or broken stone imported from some other locality. It appears that he is given a much more definite status in the preparation of his estimates by using Section 3 along the lines suggested than in any other way.

The method suggested is not entirely free from objection. It is not seen how it is possible to give 100% protection from risk in estimating. The contractor is taking risks in the element of labor and in the cost of other materials, but by making the variable the one the contractor can best deal with, seems to involve the least element of risk.

Elwyn E. Seelye,* M. Am. Soc. C. E.—Structural engineers and architects who have followed tests of reinforced concrete construction are pretty well satisfied with the safety factor obtained under present methods of design and construction, provided the abuses to be discussed are eliminated. The architect desires to know whether he will be forced to build a certain school building non-fireproof, because the Committee has increased the cost of concrete construction under its specifications.

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* Cons. Engr., New York City.

The adoption of the specifications in their present form will materially increase the cost of reinforced concrete construction and will not even give warning of many of the abuses to which concrete is subjected at the present time. The cost of construction will be increased mainly because what is considered good concrete according to present practice will be relegated to a low working stress under the proposed specifications.

The flat slab, designed under this proposed specification, will contain more concrete than if designed under the Chicago law or the New York law. In general, columns will also be larger, especially the spiral reinforced columns.

The test of any proposed concrete specifications is applied when one asks how many of the present abuses to which the material is subjected will be eliminated if these specifications are followed?

In order to apply this test, the speaker will now enumerate the faults of concrete, as it has been constructed, to the present time, and he would like to add that it should not be implied from this list that the bad things mentioned have happened to him in his personal practice, but come rather from a general observation in reading.

1.—Causes of Collapse.—Collapse of reinforced concrete structures during construction: The majority of these collapses have been clearly proven as caused by weak form design or the removal of forms at a time when, for some reason, the concrete had not developed a reasonable strength. These collapses have been shown in certain cases to have been partly due to inadequate design, but in all cases that have come to the speaker's attention, weak design has been a contributory rather than a primary cause of collapse.

Form design cannot be safely left in the hands of the practical man. Safe form design involves a knowledge of the theory of hydraulic pressure, long column action, strength of materials, and dead load computation. Therefore, one of the most vital principles in the prevention of a collapse is the inspection of forms by a qualified structural engineer. Nothing of this is mentioned under forms in the specifications.

Another important matter is the prevention of the removal of forms before the concrete is sufficiently strong to take the load. The requirement that the proper time for the removal of forms shall be determined by a competent responsible person is covered in a footnote, and should better be covered in raised type in the text.

In the case of a building collapse caused by the removal of the forms before the concrete has hardened sufficiently to bear its load, one naturally looks to the specifications for proportioning, mixing, and placing of concrete. The proposed specifications are adequate, but not sufficiently clear and practicable of application.

The usual causes for delayed hardening of the concrete are: Insufficient quantity of cement, defective cement, and the presence of impurities in the fine aggregate, and freezing.

The specifications cover the amount of cement to be used, but they do not touch on practical methods of measuring the aggregate and it seems to

the speaker that the specifications should either accept or reject definitely the prevailing method of measuring by wheelbarrows.

There is also a question of seeing that the proper number of bags of cement go into each batch. For instance, in a batch requiring two bags of cement, what assurance can be given, that in possibly one vital batch in the building, only one bag will be placed inadvertently. It is pretty safe to assume that such a thing will be inadvertent, as few contractors will take the chance of skinning cement. Possibly, if the wheelbarrow is to be done away with, the use of triple measuring bins with marks on them would serve as a check.

The specifications cover and detail the most advanced thought in regard to the protection of concrete work from many of the abuses already cited. However, they are entirely too technical to guide an inspector or contractor on a small job. They should state what is to be done with the cement which is delivered from a builders' supply company instead of coming from the mill and should recommend tests from samples taken from the site where it is impossible to have a testing laboratory make proper mill tests.

General recommendations are made in regard to forbidding the presence of deleterious material in the fine aggregate, but the recommendations are too technical and would mean nothing to a contractor or architect's inspector if such specifications, as they stand, were incorporated in the architect's specifications. For instance, how shall the decantation test be made? How shall the inspector know whether he is working in the presence of alkali soils? Will he be required to write to the American Society of Testing Materials and obtain its pamphlets on this subject?

Recent developments indicate that the presence of shale in the sand may lead to the disintegration of reinforced concrete work due to the absorbing qualities of this shale. Should not this be directly covered in the specifications?

The speaker has said nothing about the slump test recommended, because the quantity of water used in mixing, although an important factor in the strength and porosity of concrete, is not believed to have been, in the past, the direct cause of the serious concrete abuses outlined in this criticism of the specifications. He is dealing only with the most serious aspects of the manufacture of concrete rather than attempting an academic discussion of the finer points to be observed in obtaining the best class of concrete.

The recommendations in regard to protection of concrete in freezing weather are good, but so rigorous that they will be difficult to enforce.

2.—Corrosion of Steel.—The speaker feels that the specifications should state the use of galvanized steel and the use of particularly smooth forms, such as steel forms, and also the use of a particularly rich dense mixture for the concrete.

There is a great deal of cracking of concrete due to the corrosion and expansion of reinforcement in other structures than those directly exposed to sea water. This is generally due to the placing of the reinforcing steel too close to the surface, particularly in light ornamental concrete, such as bridge rails, and also to defective porous concrete.

Here, again, the use of galvanized steel is suggested and also more rigid analyses of the aggregate, and the use of a richer denser mixture.

As to electrolysis, there is a theory that if there is a difference in potential in, say, the top and bottom of a column, and if the bottom of the column is wet concrete, a current will be set up, which will corrode the steel at its terminus. The subject might be covered in the specifications in so far as to state whether or not the matter should be considered in design.

3.—Faulty Wall Surfacing.—Proper methods of wall surfacing are well covered in the proposed specifications. Decorative finishes are not thoroughly covered, and nothing is said about paints, or damp-proof coatings or interior treatment. Nothing is said about plaster bond.

4.—Faulty Floor Surfacing.—This important subject is covered in a meager fashion. Nothing is said about floor hardeners, and other materials for rendering a floor dust-proof, water-proof, and increasing its resistance to wear. Nor is anything said about paints for coloring purposes. The subject of chemical products is one on which definite information is much needed. The architect and engineer at present are much at the mercy of the manufacturer's claims.

5.—Form Deflection.—Many forms deflect during the process of concrete hardening and cause cracks in the structure. This is often caused by the settling of the mudsills of uprights, due to the softening of ground. The mere pointing out of these dangers is often a prevention, and the specifications should do so.

6.—Overloading Structures.—The overloading of the structure beyond its designed load is not clearly forbidden in the specifications.

7.—Shrinkage and Contraction Cracks.—The Committee has not yet reported on this most important subject.

8.—Foundation Settlement.—Equal settlement of foundations is more important in the design of concrete structures than for those of structural steel, inasmuch as the monolithic connections of concrete do not give and take without cracking, as readily as steel structures. This subject should be mentioned as a possible danger.

9.—Defective Reinforcing Steel.—Cases of high carbon and intermediate grade steel bars being weakened at the bends have been frequent, and it is questionable whether the minimum radius of bending should not be specified. The reliability of "re-rolled" steel is a question of common apprehension.

The Committee does not explain why it reduced the working stress for this material below that of new billet high carbon steel. The public as represented by the users of reinforcing steel has a right to know the basic facts about this matter.

10.—Water-Proofing.—The speaker criticizes the Committee's recommendations as inadequate and not in accordance with modern practice. The best modern practice for the water-proofing of basements and similar structures consists of the application of a well-bonded water-proof plaster. This method is more economical and much more easily patched than the old-fashioned membrane method specified by the Committee.

The Committee condemns the use of integral compounds which is at variance with the experience of the speaker and many of his contemporaries.

Conclusions.—If the American Institute of Architects is not represented on the Joint Committee in its subsequent deliberations, the architect will lose confidence in its specifications and will be more likely to rely on the sales engineer who will be willing to design economical structures, even if they are not up to the rules.

Many of the present abuses in concrete construction will continue, due to their not being covered by the specifications.

The cost of concrete designed and constructed under these specifications will be increased.

The specifications are not sufficiently practical to sell themselves to the practical constructor.

The specifications even as they now stand have an educational value to the technical man.

The specifications have great potentialities toward the improvement, standardizing, and popularizing of reinforced concrete, if they are made complete and presented in either the form of a technical authority or simplified with a practical working form.

The speaker regrets to appear to take a position of a critic on the invaluable work presented by a group of able men who have worked so long and so disinterestedly.

Sullivan W. Jones,* Esq.—The speaker desires to say a few words for the Architectural Profession. The architects have not been identified with the work in connection with the preparation of this report, but they are much interested in it.

Architects are responsible for the structures they design, whether or not an engineer is employed. A very small percentage of architects employ competent, consulting experts. The larger offices have experts on their technical staffs, and there is no question about the responsibility for ultimate results. The Architectural Profession deals with large quantities of concrete in structures every day, without consultation with engineers. Architects have a contribution of experience to make, and, doubtless, they have much to learn.

There are many things in this specification which seem to the speaker to be of vital interest to the architect. He has not analyzed it carefully, but understands that, generally speaking, the size of concrete columns will be increased. That is a matter of great interest to the architect, because it both increases costs and reduces the available floor area in the building. If this is good practice, if it is in the interest of public safety, let it be adopted by all means. The speaker is sure there have been no failures in New York City due to bad design. There have been many failures due to bad execution, but few, if any, that can be traced to bad design; and where floor area is sacrificed in the commercial building as well as increased cost of the work, architects are directly and vitally interested.

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* New York City.

The final results of the Committee's work should be acceptable, not merely because engineers say so, but because the architects have been self-convinced. Architects wish to co-operate with the Committee in any capacity and submit their ideas, with a view to securing perhaps a better, or, at least, a more readily acceptable specification.

George L. Lucas,* M. Am. Soc. C. E.—This specification, in the speaker's opinion, is excellent in almost every respect, and a great improvement over those in general use. However, the opposition, not only from general contractors, and contractors specializing in reinforced concrete construction, but also from engineers, makes it apparent that its adoption at this time would result in a tremendous upset in the industry, on account of its radical changes in current practice.

There is no doubt that the value of most of the provisions of the specification is generally recognized, and the specification as a whole is approved in principle, but the difficulties and dangers attending its immediate adoption and application seem far to outweigh the benefits to be derived.

Experience in subway construction in New York City has shown that the manufacture of concrete is one of the most difficult operations to control, in spite of the excellence and uniformity of aggregates obtainable in the local market. This is largely due to the numerous operations, under way at one time, by the many contractors who often are differently equipped and use different methods of working. In addition, on some of the works there are special problems in construction. It has taken years of constant effort and close supervision to approach uniformity of concrete on the various works, even under identical specifications.

Some of the many problems were, standardization of aggregates, methods of mixing, measurement of ingredients, and the use of water, apparently, all of which are easy of solution. The standardizing of aggregates, including sand, gravel, and broken stone, required changes in the methods of production, involving changes in equipment and operation in several long established commercial plants.

In order to control these materials, it became necessary to inspect them at their source, and carefully to supervise their handling, shipping, and delivery to the various works. Considerable time was consumed in accomplishing this one result. A study of mixing devices, by testing the concrete made by various types of machines, developed approved types and the time of mixing required.

Measuring methods and devices, for aggregates in common use, were constantly checked and were found generally unsatisfactory, since the measures, unless carefully watched, were subject to overcharging or undercharging, by careless workmen. Recently, the specifications have been changed, requiring measuring boxes of exact volume for each size of batch mixed, and that each and every measure be struck. A provision has been made, also, for the control of the quantity of water to be used for each and every batch.

* Div. Engr., Transit Comm., New York City.

The revision of even a minor provision in the specification, such as that covering the measurement of aggregates, may require considerable study before arriving at a satisfactory solution. The provision referred to is designed to produce a more nearly exact method of measuring, and was adopted only after practical tests on the works demonstrated a marked increase in strength of concrete due to accurate measuring.

When it is considered that, during the building of Rapid Transit railroads, there were, at one time, under construction in four Boroughs of New York City, 60 works under separate contracts, the problems to be met were similar, in a sense, to those that will be encountered in promulgating a specification for general use no matter how broad and all-inclusive it may be. For complete success, a careful and perhaps gradual introduction of the various provisions of the specification is necessary.

The results obtained by accurate measuring were developed by a test of concrete made on the work, using the contractor's workmen and equipment for mixing, and the engineers of the Transit Commission for measuring aggregates and water. The mixer was of the rotary type, using one bag of cement to the batch. The aggregates were standard inspected sand and gravel, taken from the contractor's stock piles; accurate measuring boxes were used and all measures were struck. The water was accurately gauged and for each proportion of aggregates used, did not vary more than a fraction of 1% by volume. The concrete was made in three proportions: 1:2:4, 1:$2\frac{1}{2}$:4, and 1:2:$3\frac{3}{4}$, poured into forms, and simultaneously into 8 by 16-in. cylinder moulds for test specimens, nine specimens being made for each proportion. The results of the tests on these specimens were remarkable in that the compressive strengths were far beyond the usual strengths obtained heretofore on the work. Although the control of water, no doubt, had a decided influence on the strength, nevertheless, from experience with concrete of similar consistency, the evidence proved that the accurate measuring of aggregates had a decided influence on the strength obtained. The cylinder specimens were made by simply pouring the concrete into the moulds with only sufficient manipulation to fill them completely, no tamping, ramming, or shaking being permitted. This method of making test specimens was adopted for giving comparative strengths of concrete made on the various works and for the purpose of standardizing and improving concrete manufacture. It was necessary to make specimens this way on account of the various consistencies used. It is practically impossible to adopt a uniform method of manipulation, approaching that of the concrete in the structure. The strength of the specimens, therefore, does not represent the strength of the concrete in the structure. Concrete test specimens cut from the wall are stronger than the cylinder test specimens made from the same concrete, due, no doubt, to the manipulation received by the concrete in the structure and the head under which it is cast.

The moulded specimens are tested at 28 and 90-day periods, and the specimens cut from the structure are tested at the 90-day period only. Neither the cylinder specimens nor the specimens cut from the wall are stored under

conditions identical with those surrounding the structure. The cylinder test specimens when poured are allowed to set in the moulds for 48 hours on the site of the work. They are then transferred to the curing room, stripped, and stored. The specimens taken from the wall are cut about 30 to 60 days after the concrete is placed, then dressed and placed in the curing room with the cylinder specimens for the remainder of the period.

In the speaker's opinion it would be entirely impracticable to rely on specimens cut from the finished concrete on work under construction, for the purpose of determining the suitability of the work as it proceeds. The specimens certainly determine the strength of the particular concrete from which they are cut, but in case of their failure, there would be difficulty in proving the unsuitability of all the concrete by tests of specimens taken from one part of the structure. The engineer's supervision and control of the manufacture of concrete should be such as to assure him of its quality while being placed, and he, in general should assume the responsibility as to the character of the concrete. He can determine by tests in advance of construction the quality of aggregates and the proportions of each necessary to produce satisfactory concrete.

HERBERT W. GODDARD,* ESQ.—The usefulness and success of concrete for structural purposes depends to a great extent on its ultimate cost and its ability to fulfill requirements as to strength and durability. Consequently, it is of interest to the client that the formulas, stresses, method of design, execution, etc., be considered with great care, otherwise concrete will be dangerous, if the formulas, etc., are too liberal; and if the requirements are too rigid, the cost will be prohibitive and thus prevent the project from proceeding or will necessitate, in many cases, the use of non-fireproof construction.

The speaker desires to make a suggestion, using Section 28 as an illustration. Would it not be to the interest of all concerned to review and modify items or sections, capable of more than one interpretation or of an indefinite nature, in such a way that only one interpretation can be made and only one person responsible from the time of its inception to the time of completion of any specific item. The second alternative of Section 28 begins, "The contractor shall use materials * * *", which means that when the contractor estimates on work as specified under this Section he makes his own selection of aggregates and proportions on which he puts a price. Assume that the work is awarded to him. What happens next? This Section then states, in effect, that the engineer shall make the determination. The responsibility and authority are then apparently transferred from the contractor to the engineer, and, it would seem, place a burden on the cost of the work to the detriment of economy. The contractor who has studied this section, will certainly figure what he thinks is right and then take a guess on what he thinks the engineer will do later. Divided authority and responsibility, or, matters capable of more than one interpretation, do not make for harmony, accuracy, or economy, all of which clients have the right to expect.

* Chf. Engr., John R. Wiggins Co., Inc., Philadelphia, Pa.

L. E. KERN,* ESQ.—There is one possible use of this specification, on which the speaker has heard no discussion. The architect in the smaller cities frequently has rather small reinforced concrete work, such as three or four-story warehouses or small office buildings. He wishes to use reinforced concrete floors, but it is exceptional if he has any one in his office who can design them properly. A representative from a manufacturer of reinforcement comes to him and will offer to design that concrete floor for nothing, and the architect accepts the offer. The architect often feels that he may be criticized if he limits competition and, therefore, he inserts the phrase "equal to" or "approved". Could there not be a specification for reinforced concrete, whereby the architect could tell the manufacturer's engineer to lay out and calculate the work according to this specification?

For a large part of both reinforced and plain concrete work, the specifications could be prepared so that they could be complete, full, and clear, and incorporated in the specifications of the architect or engineer without having to be copied.

Sometimes a question in dispute, or difference of opinion, could be settled by specifying the result rather than the method. It is the result that is wanted. For example, architects do not specify that woodwork shall be given two coats of such and such materials applied in certain specific ways, because they want any one of those materials or methods. They would much rather be able to specify that the woodwork shall be according to a registered sample and that the finish shall neither crack or peel or otherwise disintegrate for three or four years. However, it is not practical to do this. Much of the discussion has been about methods, and it would appear that, in some cases, at least, the easiest way would be to specify the result and not the method.

The specifications for architectural terra cotta will serve as an example of what can be done along this line. The National Terra Cotta Society devoted about six years to finding out what was bad terra cotta, and the specification it had prepared listed what was bad terra cotta. Architects were not interested in bad terra cotta, except that they did not want it. The specifications are now being revised and attempts are being made to specify what is good terra cotta. In the Tentative Specifications some of these principles might be applicable and might be of assistance in clarifying some of the points on which there are differences of opinion, especially when the differences are those of method rather than of results.

W. N. PATTEN,† M. AM. SOC. C. E.—There are one or two points in connection with the Tentative Specifications that seem to be important from the standpoint of the contractor. Section 28 implies that the contractor shall maintain a laboratory on the job or, at least, that he provide the facilities by which tests of concrete cylinders can be made in advance of starting the work.

Experience indicates that there is a great variation in the strength of test cylinders, and the speaker has in mind a job where the tests varied greatly, even though they were made under the direct supervision of the architect.

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† Constr. Mgr., Stone & Webster, Inc., Boston, Mass.

There was so much variation, and some of the samples tested so low, that it brought up a grave question about the safety of the work; and in order to arrive at some proof of the strength of the concrete in the building, test specimens were cut from the wall and trimmed down to the dimensions necessary for testing. The test specimens cut from the wall showed much higher strength than the cylinders which were taken from the mixer at the time the wall concrete was poured. The tests removed all doubt as to the value of the concrete in the building. It seems to the speaker that tests made from aggregates that vary greatly, even from the same source of supply, are not of much value in fixing the mix that must be used in order to arrive at a predetermined strength; in other words, the specification presumes that concrete can be purchased in much the same way as structural steel, and it does not seem possible in the present state of the art to determine the exact strength of concrete, even from a mix of certain definite proportions, owing to the variable characteristics of the aggregates. This specification places on the contractor a responsibility he should not be expected to assume in the present state of the art.

Improvement in methods of mixing, measuring, and proportioning the water may eventually permit the determining, at least a great deal more closely than is possible at the present time, of the resulting strength of concrete.

Another point in connection with the specification, which seemed rather drastic, is the provision, Section 79, that no integral water-proofing shall be used. The speaker has seen many instances where integral water-proofing with hydrated lime or some of the prepared mixtures on the market have given results at less expense than membrane water-proofing. He has seen failures in membrane water-proofing, as well as many instances where satisfactory water-proofing has been obtained by the integral method, at little extra cost over that of the concrete.

Section 31, "Time of the Mixing", calls for an interval of 1½ min. for mixing, with the mixer revolving at a peripheral speed of about 200 ft. per min. It is believed possible with a properly designed mixer, revolving at the proper speed, to mix thoroughly the ingredients in less than 1½ min. and obtain satisfactory results. The main consideration is to arrive at the minimum cost of the completed structure, and if it is possible to mix concrete satisfactorily in 1 min., instead of 1½ min., it would be possible to reduce the labor cost. There appears to be no reason for placing such a limitation on the time of mixing, providing it can be done properly in less time.

D. H. Dixon,* Assoc. M. Am. Soc. C. E.—The speaker is convinced that it is difficult to write a specification for concrete and reinforced concrete, which will be satisfactory for use in connection with such different forms of construction as buildings, roads, bridges, reservoirs, retaining walls, etc. The results desired in these different forms of construction are not the same. For the building of a road it may be necessary to write a specification which places great emphasis on the strength and resulting resistance to abrasion of the concrete at the 28-day period, whereas, for buildings and many other struc-

* Vice-Pres., Turner Constr. Co., New York City.

tures, the strength of the concrete at 28 days is of minor importance as compared with its strength at the later periods. In attempting to write a specification of universal scope, the tendency will be to insert provisions sufficiently drastic to provide for the most unfavorable condition that may be encountered in any one of the various forms of construction.

The writing of a universal specification requires the use of many alternates, which is objectionable, unless the conditions under which the different alternates are to be used, are clearly set forth. It is difficult to insert desirable explanatory and cautionary clauses in a standard specification and, therefore, it is well to consider whether greater benefit would not be secured if the conclusions were in the form of recommended practice rather than as a formal specification.

QUALITY OF CONCRETE. MATERIALS. PROPORTIONING AND MIXING CONCRETE.

By Messrs. Eugene Klapp, H. S. Mattimore, A. N. Talbot, Daniel E. Moran, F. W. Scheidenhelm, Walter D. Binger, Duff A. Abrams, W. A. Slater, Elwyn E. Seelye, Herbert W. Goddard, H. A. Davis, and D. H. Dixon.

Eugene Klapp,* M. Am. Soc. C. E. (by letter).†—The outstanding feature of the Tentative Specifications are the three alternate provisions for "Proportioning", Section 28. The writer is of the opinion that Alternate No. 1 and No. 2 are neither reasonable nor practicable of application.

When a construction job is under consideration, the engineers are charged with the duty of studying the site, designing the structure, and specifying the materials to be used. The engineers have ample time to investigate the possible sources of aggregate and to make the necessary tests of different mixtures to give the results required in the design.

It is unreasonable and unfair to require the bidders to make the same investigation in the limited time usually permitted for preparing bids. There are awarded many pieces of work in which the time given would not permit of a 28-day test, and considering the possibility of a failure of such tests, if made, there would be no succeeding 28-day period to permit the bidder to test a different mixture.

The profession should not forget that the bidders are taking the major chances and that all efforts should be made by the engineers to reduce these chances to a minimum, not only for the reason of fairness, but also, of economy in the cost of the work.

It appears to the writer that both Alternate No. 1 and Alternate No. 2 will affect a shirking of the engineer's responsibility. There is no practical method of adjusting the contract in case concrete already placed in the structure is found defective after the receipt of the report on a 28-day test. The speed with which concrete is now placed would insure in most cases that the defective material was completely buried in subsequent construction before the receipt of the report of test, leaving only a financial adjustment available. One can conceive of no more effective incubator of lawsuits.

There is no just analogy between such requirements for concrete as for other material such as steel, for example, because, in the latter case, the material can be and always is tested before being incorporated in the work, and its failure to comply with the requirements of the test will lead to its rejection, whereupon it is sold for some other work in which the requirements are not so rigid.

The writer sees no objection, however, to incorporating with Alternate No. 3, a provision in the general sense of the following: "The Contractor may submit at any time during the progress of the work an alternate mixture from that above specified which if proved to the satisfaction of the Engineer

* Cons. Engr. (Parsons, Klapp, Brinckerhoff & Douglas), New York City.

† Received by the Secretary, December 8th, 1921.

will give the strength desired and specified, will be accepted in lieu of the mixture above specified".

In this manner, the engineer will still maintain the responsibility of properly studying his problem before asking bidders to risk their money and reputation, at the same time, permitting the substitution of a cheaper mixture if the contractor is able to prove its unquestioned sufficiency for the strains assumed in the design.

H. S. Mattimore,* Assoc. M. Am. Soc. C. E. (by letter).†—In Section 3, as worded in these Specifications, "quality of concrete shall be expressed in terms of workability, as determined by the slump test and of the compressive strength at twenty-eight days". The writer believes that in this statement, too much dependence is placed on the slump test, because from past experience he has not found it reliable. This test is effected by factors other than the so-called consistency of the concrete, for example, the size of coarse aggregate, and, to some extent, qualities of both fine and coarse aggregate. Consistency is now being studied and the writer would not be surprised, if the slump test is ever standardized, that it will be of a different shape mould than used at present.

The writer believes this Section 4 refers only to Paragraph 2 of Section 28 and, therefore, if used at all, should be placed under that paragraph.

Chapter V is sub-divided into three methods of proportioning. The first paragraph of Section 28 outlines practically the method used at the present time, with the qualifications that these proportions be based on concrete tests made by the engineer. In such cases, the engineer is the one responsible for the quality obtained. In Paragraph 2, Section 28, the responsibility apparently rests entirely with the contractor. The writer can conceive of this being workable with some of the large construction companies which have ample facilities for testing and investigation, but such facilities are the exception rather than the rule in contracting organizations. There is also, the assumption that the strength of concrete can always be predetermined from moulded test specimens. The writer does not believe that such is the case, at least, after doing a considerable amount of work along this line, he has found that specimens, cast under field conditions, do not always indicate the strength of the finished concrete, with any degree of accuracy.

Under this method he also can see where, if the materials change to any extent, it will require changes in proportioning, which, in many cases, would be difficult. Each contract would have to have connected with it a field testing laboratory.

Under Paragraph 2, apparently the engineer assumes no responsibility for the quality of the concrete, and from this standpoint, he should have very little control over it, but the test specimens would be made under his supervision, and he would have to decide whether the quality had been secured. In cases where it had not been secured, the writer has been interested to know what the procedure would be. When one considers that concrete tests are usually

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† Received by the Secretary, December 2d, 1921.

made at the 28-day period, he can realize that some work would be finished before the quality is ascertained.

In Paragraph 3 of Section 28 it is noted that predetermined proportions are to be used from Table 4, attached to this report, which gives the proportions of various kinds of aggregates to meet a certain strength test. This theory of proportioning has been discussed with considerable length during the past several years, and along with its good points, many objections to its use have been presented. The writer believes that it could be used as a guide where the engineer wishes, but it should be so stated in the text, rather than to advise its use.

A. N. Talbot,* Past-President, Am. Soc. C. E.—The three methods of specifying the quality of the concrete as given in Section 28 differ considerably. The speaker is not sure that he understands one feature of the first method. It states that "the proportions shall be 1 part of Portland cement, ... parts of fine aggregate, and .... parts of coarse aggregate, as determined by the engineer", and in the footnote states that "the engineer shall fill in these blanks", presumably, sometime before the concrete is mixed. At first the speaker thought that it was the intention to have these filled out before the contractor's bid was made, but he cannot see how a contractor can bid intelligently on proportions that are to be filled in afterward by some one else; the contractor will be much in the dark as to the proportions desired by the one who will have the decision. The first method, it seems, may well be modified somewhat, as, where materials of a certain character are available and the proportions are agreed on in advance, so that the contractor may be able to make his bid with advance knowledge of the requirements.

With reference to the second method the speaker is not surprised that the contractor is unwilling at the present state of the knowledge of concrete, to take the risk, to assume the responsibility. On the side of the owner, especially the public, in public works, there is another reason why this method may be undesirable. There are good contractors and other kinds of contractors. This discussion has been about those who are reliable and trustworthy. If one had to deal only with responsible contractors, it would all be easy. There is also a difference between private work and its control and public work which has to be done under certain restrictions and in certain ways.

Another matter of importance is that if the contractor determines the proportions, the engineer would have to give up control. No longer could he say, you are not using enough cement or you are using too much water or that the concrete is not being mixed well enough. He would have to give the control to the contractor and then, later, assume the burden of proof if he thought the construction faulty. It seems to the speaker that the engineer ought to retain that control and that responsibility, especially on public work.

There is another matter that seems to need consideration. The tests are to be made on field concrete, with the quantity of water which is to be used in the concrete put in the work. The specimens made with considerable water,

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if it is reinforced concrete, will have to meet the required strength. When this wet material is placed in the structure, some of the water will be worked out, and, therefore, the resulting concrete will be better than the concrete in the specimens. It does not require much work to take an appreciable quantity of water out of concrete. Tests on concrete of such a consistency as would be used in a building, the mixture containing 40% more water than that which is ordinarily known as normal consistency, showed, with the use of a light roller lightly applied, a reduction of 8% of the water or from 1.40 relative water content to 1.29. Spading the concrete, as is frequently done in placing the concrete around in the forms and allowing the excess water to run off, took out 12% of the water, reducing the relative water content to 1.23. Tamping the concrete by placing a plank over it and using a pneumatic hammer for a short time, took out 12% of the water. Ordinary methods of tamping took out 12% of the water. This reduction in the water content before the concrete has taken its final position and before it begins to set, will result in a strength very much the same as though the quantity of water finally in the concrete had been used in mixing it originally, and, therefore, will result in a greater strength than that given by field specimens.

Not many discussors have referred to Table 4 in connection with the third method of specifying quality given in Section 28. The speaker would not be willing to accept Table 4 as a specification. He thinks he would be unwilling to use it in work of which he had charge. Judging from his knowledge of concrete, it is uneven in strength. It will produce concrete uneven in workability for the same slump. Of course, it is a striking example of the increase in cement content required with an increased slump; the values in some places for 2 000-lb. concrete give a quantity of cement in a cubic yard of concrete for the 8-in. slump, twice as great as that for 1-in. slump. Thus, it emphasizes the increased cement required for the wet mix. It would appear that for the materials the speaker has used, some of the mixes will not give the desired strength and others will over-run. This goes to show the difficulty of making a table that is at all general, or which may be used as a specification or even as a guide. Some of the mixtures seem not to provide for a good quality of concrete. A somewhat different proportioning of the same materials might well be used in some cases with a resulting better quality of concrete, or the mixture might be changed to require a smaller quantity of cement.

Although great advances have been made, the state of the art is not yet perfected. Good concrete has been made for many years, but further knowledge is needed. The slump test, of course, is not an accurate means for determining the workability of concrete for all varieties of material. Certain relations that have been used, are of advantage in making comparisons; the water cement ratio is useful for the same materials, but not enough is known to state that it can be used in a comparison of different classes of materials and different proportions. A law may be apparently true as the average of a large number of tests for materials of a particular kind; materials used on a single job may vary considerably from this law, so much so that the law

may not properly be used for specifying what the mix should be. The speaker says this because he feels that more information is needed before accepting some of the newer methods of specifying the proportioning of concrete.

Daniel E. Moran,* M. Am. Soc. C. E.—In Section 26, it is stated that the unit of measure shall be the cubic foot; and in Section 27 it is stated that the material shall be measured by volume or weight. The speaker thinks that the unit of measure for volume should be the cubic foot. He objects to the principle involved in the first and second paragraphs of Section 28, in that the test of the concrete is to be determined long after the materials have been mixed. It seems to the speaker that it is a thoroughly impracticable specification. It leaves to the contractor the determination of the proportion in which he shall mix the materials that have been so specified, that a definite and desirable result shall be achieved. It seems that it is the engineer's job to instruct the contractor in what proportions, and of what materials the concrete shall be made. The same criticism applies to the third paragraph of Section 28, "Proportions", because, in case the aggregate varies, it may be used provided the new proportions determined by the engineers are such as to produce concrete of the required quality. It seems to the speaker that the duty of the engineer is to see that the cement, the sand, and the aggregate are of proper quality, and then, to see that the contractor mixes them properly. To tell the contractor, however, that he must mix materials such, that, at the end of 28 days, the concrete shall be of a certain strength, leaves it open for the contractor to ask the engineer, "How shall I mix it to attain this strength?" Moreover, in the practical execution of work under these specifications, if the concrete in place, did not come up to the 28-day specification, the engineer could call on the contractor to remove it. In the speaker's experience, it would be difficult at that time to obtain the owner's, or the contractor's consent to the removing of work that had been placed under the engineer's specification. If the engineer allows the contractor to use certain proportions of the materials he has specified and, later, condemns the work because the laboratory strength is not the same as is wanted at 28 days, then the order to remove the concrete is unreasonable and unenforceable.

Under Section 30, "Mixing", and under Section 31, "Time of Mixing", it is stated:

"The mixing of each batch shall continue not less than 1½ min. after all the materials are in the mixer, during which time the mixer shall rotate at a peripheral speed of about 200 ft. per min. The volume of mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer".

This passes the responsibility to the manufacturer of the machine. He is asked to rate the machine and then his rating is used as a measure. What is to prevent a manufacturer from over-rating his machine?

F. W. Scheidenhelm,† M. Am. Soc. C. E.—The speaker has some remarks to offer on the subject of Chapter V, with particular reference to proportioning. The object of the new specifications is to make available to the pro-

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† Cons. Engr. (Mead & Scheidenhelm), New York City.

fession recent advances in the art of making concrete and reinforced concrete: First, there are the advances in design; and, second, there is the progress in the manufacture of concrete. The latter is the subject under discussion, particularly as concerns the grading, measuring, and proportioning of the aggregate and the selection of the appropriate proportions of cement and water. Third, there is the subject of tests, especially tests to determine the quality of the finished product.

The problem the Committee has before it, is to decide how best to make the advances in the art available to the profession. The speaker will revert to this subject merely to express his growing doubt as to the advisability of presenting an outright specification. His inclination would be toward the presentation of a statement of recommended practice. Such a statement has the advantage of being more tolerant than a specification. In fact, it would permit a presentation of alternatives, and in some cases perhaps even minority reports would appropriately be included. Surely it is not for the best interests of the profession to set forth a point with all of the appearance of settled authority when actually it is still a matter of debate.

The beneficiaries of this admirable work of the Joint Committee are primarily the engineers and the architects. If they are to be the only beneficiaries, there would seem to be no need for such alternatives as are set forth under Section 28, "Proportions". In that event a specification, or recommended practice might preferably be put forward, whereby proportions are determined and varied according to the results of tests. Where the making of tests is impracticable, a table such as Table 4 could be presented. In view of the fact that a statement of recommended practice would not be clothed with the authority of a specification, it would seem that there would be less danger that clauses might be blindly copied for situations to which they are inapplicable.

However, the Committee has gone so far as to attempt to make the advance in the art applicable to the relations between the owner, the engineer, and the contractor. The kind of contract referred to is that which is let on a lump-sum basis or on a fixed unit price basis. On the subject of proportioning (Section 28), three options are submitted. For the purpose of examining these three options, let it be assumed that it is desirable to draw rigid specifications, applicable to contracts.

The striking feature is the second option, which clearly places responsibility on the contractor. In order that the speaker's point of view may be clear, he wishes to state that at different times he has played the rôle of the engineer and of the contractor and, therefore, has sympathy for each. The advantages and disadvantages of placing such responsibility on the contractor are somewhat as follows.

The advantages appear primarily to be two in number: First, the clause fulfils a desideratum from the viewpoints of both owner and engineer, in that it involves a guaranty of performance. Such guaranties of performance are generally desirable. In purchasing an electric generator or an hydraulic turbine, it is practicable to specify the efficiencies and to refuse to accept the machine or to make payment in case the efficiency guaranties are not

met. Undoubtedly, guaranties of performance are in general more readily obtainable by the mechanical engineer than by the civil engineer, taking into account the differences between the machines or materials with which they respectively deal. Even in the Civil Engineering Profession, it is entirely practicable, for instance, to obtain structural steel that will meet specific guaranties. These guaranties are tested by means of specimens, such tests generally being made before the material is shipped, and, in fact, before it is even fabricated. Test specimens of steel offer a better indication of the strength of steel than tests of concrete cylinders or other concrete test specimens, offer with regard to the strength of the structural member to be manufactured from concrete of a similar character. The art of manufacturing concrete has not yet progressed to the point where it is possible to deal with concrete in the same manner as with steel.

The second advantage is that, under this guaranty-of-performance option, contractors would find an incentive to lend their utmost assistance toward obtaining the desired result. It is no slur on contractors in general to state that the second option is preferable from this standpoint.

As to the disadvantages, the first is, that this second option allows or forces the engineer to "wash his hands" of responsibility. Should he be ready to do so? The propriety of supervision of the manufacture of concrete has been admitted almost universally. The speaker believes that there is more need of that supervision at present than there has been in the past, in the sense that the need of supervision is recognized even more keenly. There is an important piece of concrete work involving some millions of dollars with which he has been associated and on a part of which there has been trouble as to the quality of the concrete. The work is not finished. If the work were to be completed, and the speaker were to be connected with it as an engineer, he would not wish to avoid responsibility for that concrete; he would not willingly allow a contractor to pursue such methods of manufacture of concrete as the contractor pleased, limited only by the requirement that certain test cylinders show a proper test strength at the end of 28 days.

This leads to the second disadvantage, namely, that the tests of cylinders, as proposed, would not show accurately or reliably, the strength of the finished material or structural member, in place. Evidence on this point was given by Mr. Lucas, who stated that, from a consideration of many tests, made under his supervision for the Rapid Transit Commission of New York, it is clear that the results from test cylinders vary and are inconsistent. He was positive that the results of tests of cylinders cast separately are not typical, or at least are not reliably indicative, of the strength of the finished structure or of the strength of test specimens cut from the finished structure.

Third, it is believed to be unfair to place such responsibility on the contractor. One might even say that it is unethical. The engineer should not shirk responsibility. The speaker agrees fully with Mr. Moran's statement as to the unfairness of making a contractor wait for 28 days before he knows whether the piece of work he has erected, is going to be accepted. If the work is reinforced concrete building construction, involving a number

of stories, it is not unusual for a contractor to erect a building at the rate of a story every 7 or 10 days, so far as concerns the columns and floor slabs. On the basis of the 28-day cylinder tests, the contractor might easily erect two or three stories above a given floor before he could learn whether that floor was acceptable. He is entitled to know much earlier whether his work, and, in particular, his proportioning, is acceptable.

A fourth disadvantage lies in the difficulties of making the scheme practicable. These difficulties are mainly of other than an engineering nature. They are indicated somewhat by the fourth footnote, page 74.* Inquiry has elicited information that it is not contemplated that the contract clause (indicating "procedure to be followed in case tests show that concrete of the specified strength has not been obtained") should preclude punitive measures, involving presumably monetary penalties, nor remedial measures, nor measures for the control of the further manufacture of concrete for the work. Measures for the latter purpose would really be the most important; but, as regards such measures, the same result can be obtained by other means, as will be pointed out. Measures involving penalties, on the other hand, could only lead to lawsuits, and remedial measures, to the extent that they involve replacements at the expense of the contractor, would likely lead to the same end.

Consideration of the foregoing advantages and disadvantages indicates a marked preponderance of disadvantages, not merely in number, but also in importance. Under all conditions, therefore, the speaker would strike out the second option.

Where tests cannot be made, the third option seems to be satisfactory. For contract work that is of sufficient importance to support the making of tests in advance of and throughout the progress of the work, it is proposed to modify the first option as follows:

(1).—For the information of all concerned, state the aim as to strength (that is, by reference to Section 4).

(2).—Specify consistency (that is, by reference to Section 29).

(3).—State sources of supply and classes of fine and coarse aggregate.

(4).—Specify tentative proportions, based on the grading of the aggregate and the required workability, or on actual tests.

(5).—Provide for subsequent variations in the proportions of the aggregate as between fine and coarse aggregate, such variations to be specified by the engineer in the light of the results of tests to be made from time to time during the progress of the work. In general, a contractor will readily assume, without additional charge, the risk of minor losses which might result from variations in proportions of aggregate. The speaker had experience with an important contract job where the contractor agreed in advance to make changes in proportions of aggregate from time to time as the engineer might specify. The speaker asked the opinion of the chief engineer of one of the most important contracting companies in the field of concrete and reinforced concrete and was informed that, in his opinion, the resulting differences in cost would be negligible.

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* *Proceedings*, Am. Soc. C. E., August, 1921.

(6).—Provide for corresponding variations in proportions of cement to aggregate. Unlike the preceding adjustment, however, variations in proportions of cement call, in fairness, for a money adjustment with the contractor, according to the difference in quantity of cement actually required, as compared with the quantity required under the tentative proportions. Such a provision is actually workable. Under an alternative method, the owner would furnish all of the cement, f. o. b. cars or trucks on the work. This alternative was utilized by the speaker on a piece of work without involving difficulties, despite the fact that the work was of importance and the contractor of the kind who does not avoid making difficulties.

A specification such as proposed in the foregoing possesses the advantage that the engineer has the concrete under control throughout the job, however, without involving any unfairness to the contractor. There is nothing to prevent co-operation of the contractor toward the mutually desirable end of obtaining concrete of the best practicable strength and greatest practicable life. Reputable contractors would naturally do their utmost toward that end. In fact, it is to the advantage of the contractor to do so from the standpoint of self-interest, for no contractor desires the reputation of having made poor concrete, and the records of failure are entirely too many.

Finally, if specifications are to be applicable to fixed lump-sum or fixed unit price contract work, and if the three proposed options are to be retained, certain minor suggestions are offered:

As to the first option, Lines 2 and 3: Quality is in Section 3 defined in effect as including strength and workability. Therefore, in the present connection, the word "strength" is superfluous. Perhaps it would be better still to specify that the proportions shall be such as to produce concrete of the strength specified in Section 4 and of workability (consistency) as specified in Section 29.

First option, Lines 4 and 5: The phrase, "as determined by the engineer from concrete tests of the materials to be used", should be placed in a footnote because it merely recommends the means whereby the engineer may fill in the blanks.

Second option: In cases where the second option is used the first and third options would not appear; the second option, therefore, should contain further definition of "required workability and strength", presumably by reference to Sections 29 and 4, respectively.

Third option, Lines 2 and 3: The statement that "the proportions of materials shall be selected from Table 4, should likewise be placed in a footnote.

Third option: It would seem advisable to specify workability. In fact, workability must be fixed in order that the engineer may specify proportions, for, in order to utilize Table 4, he must enter it by means of an assumed slump, which is stated to be the measure of workability.

Walter D. Binger,* Assoc. M. Am. Soc. C. E.—A little more than a year ago, the following order was placed with one of the leading testing laboratories:

* Vice-Pres. and Treas., Thompson & Binger, Inc., New York City.

"We desire to know the best proportions of cement, and the aggregates at our disposal, to use in order to obtain a mixture having a compressive strength of 2 400 lb. per sq. in. at 28 days."

A report was received which contained full specifications governing the test, together with the following statement:

"Our calculations and experience indicated to us that the mixture of 1 : 1½ : 3 was most likely to bring about the required compressive strength of 2 400 lb. per sq. in. at 28 days."

The results secured by this testing laboratory were, on the whole, satisfactory. The three 6 by 12-in. cylinders, crushed at 28 days, had a compressive strength, in pounds per square inch, of 2 326, 2 248, and 2 209, respectively, or an average of 2 261. These tests were made within one day after the cylinders had been removed from the damp sand. The data used in securing the above mixtures were:

Maximum size of aggregate	1 in.
Fineness modulus of the aggregate	5
Relative consistency	1.07
Proportion, fine to coarse aggregate	43 : 57
Desired strength	2 400 lb.
Cement to aggregate	1 : 5

The laboratory suggested a 7½ in. slump for the tests, which was agreed on as it was necessary to chute the concrete. The area of the building was so small that it was essential for men to be working practically all over the floor while the concrete was being poured. From past experience it had been found that a slump of between 7 in. and 8 in. for concrete with small-sized aggregate, averaging less than 1 in., such as was being used, gave satisfactory results.

A contract was entered into with another prominent testing laboratory to take complete charge of the making, curing, and crushing 6 by 12-in. cylinders of the 1 : 1½ : 3 concrete, to be used in the columns. It was agreed that three cylinders should be made from the column concrete of each story. The tester took the samples in small lots from the chutes until he had secured a sufficient quantity to fill a cylinder with concrete that he considered representative of a single column. In the usual manner, the cylinders were kept in damp sand at 70°, and tested at 28 days after having been exposed to the air 1 hour.

The results were astonishing, and caused some concern until it was realized that they were not indicative of the true quality of the concrete of a particular column and its variation from the others. One or more daily slump tests were taken throughout the operation, and the water at the mixer measured with a fair degree of rigidity. The slumps averaged 7½ in., probably never being much less than 7 in., or more than 8 in. Mention will be made later of the conflict here with Table 2 of the Specifications.

Although conditions were fully as uniform as they are likely to be on an average concrete structure, results were secured which seem to be erratic, when one contemplates the individual test specimen. The average for all tests is 2 151 lb. per sq. in., and the plus or minus average deviation of the individual

cylinder from the mean is 224 lb., or 10.4 per cent. It seems to the speaker as though that is so great as to make the individual cylinder a questionable criterion.

In case it is thought that the results to be obtained from the average of any three cylinders, as representative of the concrete in the columns of a particular story, might be better, it is worthy of note that the average plus or minus deviation from the mean of all tests, considering the cylinders of each floor as representing a point, is 211 lb., or 9.8%, or very little better. The concrete in these columns is probably very good, considering that the average, of 2 151 lb., is from cylinders tested after only 1 hour's exposure to the air. It would probably be correct to assume a 30% increase for completely air-dried specimens, or about 2 800 lb. Data on cylinders, which will soon be broken, after having been air-dried for one year, are not yet available.

Let these results be considered in the light of the new Tentative Specifications. From Table 4, it is doubtful whether 1 : 1½ : 3 concrete should have been used though the variations from these figures would not have been great. Probably 1 : 1.6 : 2.3 would have been satisfactory had the slump not exceeded 7 in. and the aggregate been proportioned by weight.

Here is a point of great difficulty. First, the slump test, as used under working conditions, is, in the speaker's opinion, not accurate to ½ in. Further, the maximum slump of 6 in., given for columns in Table 2, although desirable insofar as it makes for stronger concrete, is difficult of use in a structure of the type under consideration, as the surfaces of the columns, which contain a high percentage of both hooped and vertical steel, would be unsatisfactory. Second, too great insistence on a mix, such as 1 : 1.6 : 2.3, as against, for example, 1 : 1.8 : 2.2, is making an assumption that the variation in aggregate from day to day, if not from load to load, and of slump, is not so great as to destroy the entire precision and make useless all the extra time and expense required to secure such accurate proportioning. It seems more than probable that the variation is great enough to destroy the precision.

The concrete of this particular structure was poured from October to February, and it was occasionally necessary, for a one-half day period, to change aggregates or to accept sizes different from those tested by the laboratory, as the structure was erected in a densely populated part of the city where there was no storage room and the stone companies refused to store in reserved piles during the winter.

Although these points do not, in any way, destroy the scientific accuracy of the recommendations in the Tentative Specifications, they do, in the speaker's opinion, prove that in the present state of knowledge and organization, it is impractical to follow all of them.

Duff A. Abrams,* M. Am. Soc. C. E.—Various suggestions have been made with reference to proportioning and mixing concrete, but it seems that there has been a great deal of misapprehension with reference to certain features of the recommendation of the Joint Committee. The second alternative under Section 28 was intended to give the contractor the benefit of

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the knowledge he may have with reference to the relative merits and prices of the materials available and the proportions in which they may be mixed in order to obtain a better concrete and at a lower cost than he may be otherwise required to pay. It should not be overlooked that all sections of the United States are not so fortunate with reference to concrete materials as New York City. 1:2:4 concrete may be entirely satisfactory here; in other sections of the country it would be a serious mistake to use such a mixture. It is with reference to such features that the alternate methods were provided.

The speaker does not believe that this specification, if used as a basis of agreement between the contractor and owner, would require the contractor to remove the first story of a building after the fifth story had been placed. It is well known that there are methods of improving the concrete after it is in place, such as additional curing, by keeping the concrete wet or damp, or by supplying heat, if necessary. That will make a material improvement in the quality of the concrete without the necessity of removing it. If the necessity arose, would it not be better to remove a story than to have the building collapse, as sometimes occurs?

A great deal of the concrete that has been produced during the past few years, under so-called standard methods, is not satisfactory. If the concrete industry is to progress as every one wishes it to do, a better average of concrete must be produced. The speaker has in mind a large building, which has been in service only five years, yet some parts of the structure are in a serious condition, and will require extensive and expensive repairs. The speaker cannot believe that the owner of that building got what he thought he was going to get or had a right to expect from the contractor. The contractor was undoubtedly reputable, and thought he was delivering a good job; however, through carelessness or ignorance, he did not deliver a good job.

Many similar instances might be cited. A case has been reported recently of a building collapsing before construction was completed. A building would never collapse, under these conditions, if the concrete materials had been studied and tests had been made during the progress of the work as contemplated by the Tentative Specifications of the Joint Committee. Defective design sometimes creeps in, but most of the trouble is due to inferior concrete. It should be emphasized also that good cement, high-grade aggregates, and a proper mixture of cement and aggregates do not insure a good concrete. The one thing that has been emphasized above everything else in the Committee's studies of concrete, in the laboratory and from observations of the results of concrete work in the field during the past five years, is the fundamental importance of the quality of mixing water and the necessity for proper curing conditions. A batch of concrete mixed to a sloppy or soupy consistency may have only 20 to 30% of the strength that should be obtained with the same quantity of cement and at the same cost with a proper consistency. It should be pointed out, also, that time does not remedy the faults of poor concrete, resulting from too much water. The strength test of the finished concrete is the most practicable method of determining its quality.

It seems to the speaker that the objections of the contractors may lead one to ask just what it is that the contractor agrees to furnish to the owner of a reinforced concrete building? The contractor is engaged in a manufacturing industry, on the work; no other manufacturer can dodge responsibility for the quality of his work. One does not agree to pay for other work without some guaranty of quality. The manufacturer must assume the responsibility.

The speaker desires to correct one misapprehension; the structure to which he referred was not a parapet wall, but an eight-story, reinforced concrete building—a much more important structure than the usual parapet wall. He has seen some of the concrete that had fallen from one of the lintels on the sidewalk. This reveals a condition in the building that is serious, and just such a condition as the sections in the specification are attempting to avoid. From an examination of the concrete, it is the speaker's impression that they used too much water, and that the concrete went into that building as it is going in all over the country. Much of the work being done now will show exactly the same results in five or six years. Twenty-five instances could be named of that kind, not isolated, not unimportant structures, all of them valued from $500 000 to $5 000 000 or $6 000 000. All these difficulties could have been avoided if some care had been taken to watch the quality of the concrete as it went in, without any particular reference to 28-day tests. Work on some of these structures extended over a period of several months or years. It is quite important that concrete work of this kind should be done under rigid specifications.

W. A. Slater,* Assoc. M. Am. Soc. C. E.—There is one feature of the specification as it now stands, which seems largely to have been lost sight of. This was indicated by the statement of one of the speakers that whatever the Committee decides to do, he would continue to specify the materials to be used and the proportions in which they are to be used. In expressing that idea, he is not opposing the specification as it stands and in so stating, gives a suggestion as to the manner in which the specification will work in practice.

The apprehension of the contractors apparently is that the great majority of engineers would choose the alternative under which the strength of the concrete is specified and not the proportions to be used. Others, speaking on the subject have also indicated that they believe that the proportions for the concrete should continue to be specified. This means that those engineers would choose that alternative which specifies proportions rather than strength. Is not the apprehension on the part of the contractors more serious than it need be regarding the number of engineers who would select the method of specifying by strength rather than by proportions?

Elwyn E. Seelye,† M. Am. Soc. C. E.—Table 4 indicates a remarkable difference in the strength of controlled and uncontrolled concrete. It is not to be expected that most concrete will be scientifically controlled, therefore, in the speaker's opinion, low working stresses for uncontrolled concrete should

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be recommended and attention should be called to the possibility of arriving at a greater economy and safety through the use of controlled concrete. The methods to be used for controlling concrete are too technical to sell themselves to practical men.

If possible, references to the American Society of Testing Materials should be eliminated and specific instructions should be given for the conducting of the slump test, decantation test, and tests to determine the grade of aggregate.

The Specifications are inadequate in their scope and evidently more sub-committees are needed to cover the different ramifications of concrete construction.

Herbert W. Goddard,* Esq.—The first and second alternates of Section 28, which give the engineer the option of specifying concrete by strength rather than by proportions, should not be recommended at the present time.

The second alternate of Section 28 contemplates: First, that the contractor shall use materials proportioned and mixed so as to produce concrete of the required workability and strength; second, that the engineer make frequent compression tests of the concrete used in the work, which tests require 28 days for completion. It seems to the speaker that this changes the responsibility from the contractor to the engineer.

Should the second alternate of Section 28 be adopted, it would undoubtedly be considered by the building departments of the various cities.

Another point is the questionable accuracy of determining concrete solely on the compressive strength of tests at 28 days. Certain cements do not give high compressive tests at 28 days.

The speaker wishes to suggest that consideration be given Section 28 with particular reference to the advisability of omitting the first two alternates.

H. A. Davis,† Esq.—The speaker wishes to point out that too much emphasis is given the 28-day strength test as a criterion of the quality of concrete. The rate of hardening of different brands of cement varies, and to use this test for the 28-day period as a criterion for quality of concrete would, in time, work to the advantage of quick hardening cements.

D. H. Dixon,‡ Assoc. M. Am. Soc. C. E.—The quality of concrete cannot be properly expressed in terms of slump tests and of compression tests on cylinders at 28 days.

Slump tests can only be considered as approximately reliable. General experience has demonstrated that they do not indicate the water cement ratio or the strength, with accuracy. With a wide variation in water cement ratio, the slump tests will sometimes show only a small variation.

There are two lines of thought which will indicate the undesirability of attempting to change from the present method of specifying concrete by proportions to the method of specifying a guaranteed strength of cylinders at 28 days, as suggested in the second alternate of Section 28.

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‡ Vice-Pres., Turner Constr. Co., New York City.

First.—The results obtained in testing cylinders at 28 days are known to be seriously influenced by seemingly trivial details in the making, storing, and testing of the cylinders. Even if the rules for the making of cylinders are carefully followed, the personal equation of the man making them seems to have its effect. Mr. H. W. Greene, in a paper published in 1919 by the American Society for Testing Materials, has pointed out the marked effect on strength resulting from allowing the cylinders to dry at different periods during storage. The temperature to which the cylinders are exposed has a marked effect on strength. A lack of even bearing in the testing machine has its influence.

A study made by comparing the results obtained at the leading laboratories of the country, as published in the *Transactions* of the Engineering Societies, will show a frequent lack of uniformity in tests of cylinders.

If concrete should be specified by strength of cylinders at 28 days, it would be necessary on the average building job to make the cylinders on the job and in many cases it would be necessary to ship them long distances by express for testing. Considering the influence on strength of the personal equation of the inexperienced men who would make the cylinders on the job and the uncertainties of temperature and dryness in storage to which the cylinders would be subjected at the job and while in transit, it is impossible to avoid the conclusion that frequently the test results obtained would be misleading. This conclusion is strengthened by an examination of the data published by expert investigators of tests made under the best conditions for securing accuracy. Tests which have come to the attention of the speaker on work with which he has been connected have convinced him of the uncertainties of the results obtained when based on the small number of cylinders that it would be practicable to make during the pouring of a floor in a building.

A hasty consideration of the problem might lead to the conclusion that the difficulty due to the uncertainties of cylinder tests could be overcome by providing that only a certain percentage of the number of tests made would be required to come up to the specified strength. Under such a specification the contractor would be required to occupy the position of a gambler, as for any small number of tests, the uncertainties in the testing of cylinders might lead to good results or to poor results, although made on concrete of equal quality.

Second.—Even if the results obtained on compression tests of cylinders at 28 days were not of uncertain reliability, it would be illogical to establish the strength of cylinders at 28 days as the sole criterion of the quality of the concrete.

When concrete is specified by proportions, the engineer writing the specification can have in his mind not only the strength of the concrete cylinders at 28 days, but also the strength the concrete will have at later periods in the structure.

To the speaker's knowledge, no comparative tests on specimens cut from buildings are available, but tests, made by the New York Subway, show the concrete cut from the structure to be 25% stronger than concrete cylinders made at the time the concrete was placed and dried out two days before testing.

If the cylinders had been tested wet, the difference in strength would have been still greater. It is entirely logical to suppose that excess water will drain out of concrete after it has been placed in the forms and it is a fact that if the water does drain out before the concrete starts to set, the excess water that has drained out has no injurious effect on the strength of the concrete.

A cement that gives comparatively low results at 28 days may give satisfactory results at later and more important periods. William M. Kinney, Assoc. M. Am. Soc. C. E., in a paper on aggregates for concrete, read before the American Concrete Institute, in 1912, gives a series of experiments on five different brands of cement. The brand of cement that was the weakest of the five at 28 days, was the strongest at 6 months, with a difference of about 21 per cent.

Tests by the speaker, on nine brands of cement, all of which satisfactorily passed the tests for cement, confirm the fact that certain brands used by him in his work with entire success for the past 20 years, will not give as high results at 28 days as other brands of cement.

The speaker believes that should a specification be adopted that requires the guaranteed strength of cylinders at 28 days, the sole measure of the quality of concrete, the inevitable result will be that contractors will give preference to those brands of cement that give the greatest strength at 28 days, as with such cements they can obtain a specified strength with less cement and, therefore, more cheaply. This, he believes, will work a great injustice to brands of cement that are slower in picking up strength but, as shown by Mr. Kinney's tests, they sometimes at later periods exceed the quick-hardening brands, in strength.

Section 5.—It has already been pointed out, that if the cylinders were dried three days before testing, the strength of the concrete as shown by the test would be increased about 30 per cent. In laboratory investigations it may be desirable to test the cylinders as soon as they are removed from the damp sand, in order to eliminate uncertainties in the extent of the drying, due to variations in the air in which the cylinders would be exposed for the 3-day period.

Although from the standpoint of the investigator, the testing of the cylinders when wet may be desirable, in this Specification as now written, the strength of the wet cylinder becomes the basis of determining the unit stresses to be allowed in design, and, therefore, unless the cost of work is to be materially increased, it will be necessary to provide that the cylinders shall be dried three days before testing.

The measure for the strength of concrete has been made more and more restrictive. Twenty years ago, ideas as to the strength of concrete were based on tests made on cubes. The next step was to change to tests on cylinders which, in engineering practice, were tested dry and gave strengths about 75% as large as had been obtained on the cube. This change in the form of test piece was not made because of any difficulty experienced with buildings in which concrete had been passed as 2 000-lb. concrete by the tests on cubes. The change to the cylindrical form of test was made because, in laboratory investigations, it was found to give more consistent results than could be obtained

with cubes. It is now proposed to specify that strength shall be measured by tests on wet cylinders, which will mean a further reduction in indicated strength of about 25 per cent. The suggestion for this change is not because of any experience with concrete buildings, which would make it necessary to require a richer mix of concrete, but simply to secure a more uniform method of testing.

When the amount of building that has been done with entire success with 1 : 2 : 4 concrete, calculated at 2 000 lb. is considered, and it is further noted that, through the more careful control of the water ratio, concrete placed in the future should be better than that placed in the past, it is difficult to understand why a specification should be proposed which would make it necessary to use a mix of about 1: 2: 3 to obtain 2 000-lb. concrete, unless it is the intention to increase the allowable working stresses in a proportionate amount. As already stated, comparative estimates show that the allowable working stresses and assumptions made in design have not been changed to compensate for the proposed new measure adopted for the strength of concrete and, therefore, as the specification stands, its adoption would lead to an unwarranted increase in the cost of buildings.

Section 28.—Alternate 1 attempts to specify both the proportions in which the concrete shall be mixed and also the strength the concrete is to have. It is impossible to specify both these conditions without first modifying the wording of this alternate so as to make it equivalent to the provisions now contained in Alternate 2.

Alternate 2 requires the contractor to fix the proportions and to guarantee that the concrete will have a certain strength when tested in wet cylinders at 28 days. It must be kept constantly in mind that although this is only one alternative method of specifying proportions, still, if it is left in as an alternate, probably many architects and engineers will select Alternate 2 as the basis of their specifications without appreciating the difficulties involved by such a selection. Among these difficulties are the following.

It will be impossible for a contractor to estimate accurately, work in a new location, because he will not know in what proportions his concrete will have to be mixed.

When the work is in progress, the tests of the concrete placed in a floor may fail to come up to the specified standard. In this case, the Building Department may refuse to post the floor for the live loads for which it was designed. The contractor will claim that the concrete he placed in the building was good and that the fault lies with the making and the testing of the cylinders, by the engineers. Those who have studied the results obtained in tests on cylinders, know the uncertainties of such tests, when made in limited number.

It may be taken as a general principle that any proper specification will be so drawn as to permit the engineer to inspect the structural parts of a building as they are placed so that he may know at the time the work is done that it will be acceptable. The interests of the owner, of the contractor and of the engineer all require that this condition be insisted on. Under Alternate

2, the engineer would not know whether a floor was acceptable until a month after it had been placed, or until three or four more stories had been superimposed on the floor in question. Under such a condition, the engineer who was compelled to inform an owner that the floor was rejected and then explain that his specification did not enable him to know whether work was good or bad until a month after it was placed, would occupy an intolerable position. A specification which does not permit the contractor to inspect his material in advance of its use and then know he is complying with the specification when he places it in the manner required by the specification, also creates an intolerable condition for the contractor, as it subjects him to the danger of unjust exactions.

Instead of operating to the advantage of the honest contractor and to the disadvantage of the dishonest contractor, Alternate 2 would seriously hamper the honest and conservative contractor while assisting the unscrupulous or careless contractor in obtaining work in competition.

Everything that is reasonable to wish to obtain by the use of Alternate 2 can be secured by the use of Alternate 3, when modified to provide that the engineer will specify the proportions in which the concrete is to be mixed, with the further provision that should the engineer, change the mix, as a result of tests, an adjustment in the price for the work shall be made equal to the increased or decreased cost of materials, made necessary by the change.

Section 31.—Recent tests seem to show that the gain in strength due to mixing 1½ min., instead of ¾ min., is probably about 5 per cent. Such a small gain in strength does not warrant continuing the mixing beyond the ¾ minute period in cases where the mixing water is introduced promptly. Although a fraction of a minute seems a small matter, a slight change in the time of mixing will frequently have an important effect on the amount of plant required. The 1-yd. mixers now used by contractors on large buildings are about as large as can be placed in basements and, therefore, if the time of mixing is extended, it will frequently mean placing less concrete per day in cases where monolithic finish is used, or installing a second mixer.

If a reinforcing rod is allowed near the exterior surface, moisture and air, penetrating the thin film of mortar or concrete that covers the bar, will cause the bar to rust. The formation of the rust scale will force off a small sliver of concrete which will then expose the bar to more rapid corrosion.

When signs of this trouble develop, the steel rod should be thoroughly cleaned, painted and recovered with mortar.

In recent years this trouble has been overcome in exterior columns by casting circular mortar blocks with a hole in the center which are called doughnuts. Enough of these doughnuts are slipped on the vertical column bars to keep them at least an inch from the exterior surface and to have no trouble from rusting.

Designers sometimes show longitudinal rods in the small drip members of cornices, belt courses, etc. These rods serve no useful purpose and may cause trouble by rusting.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

THE RELATION BETWEEN DEFLECTIONS AND STRESSES IN ARCH DAMS

Discussion*

BY MESSRS. L. STANDISH HALL, WILLIAM A. MILLER, AND CHAUNCY WERNECKE.

L. STANDISH HALL,† Assoc. M. Am. Soc. C. E. (by letter).‡—The writer has been impressed by the efforts made in the last few years to improve the theory used as a basis of the design of the arch dam. There is probably no engineering structure, considering the magnitude, in which precedent plays such an important part in the design. The formula that is most generally used in proportioning an arch dam, is the so-called cylinder formula. A brief comparison of the conditions under which this formula is applicable with those existing in an arch dam, will show that it is materially defective.

However, many dams have been designed by the cylinder formula, and the principle arguments to support its use are the ease with which it may be applied and the fact that no arch dams designed by it have failed. The fact that these dams have been designed according to a defective formula does not necessarily infer that they are unsafe. A large "factor of safety" is usually allowed so that the unit stresses in the concrete are much below those used in building construction where the distribution of the stresses can be calculated more accurately.

A few years ago, the writer made a study of the arch dam and arrived at conclusions, quite similar as regards the requirements of formulas to cover the actual static conditions as those developed by Mr. Noetzli. It is believed that the author's method is sound from a theoretical standpoint, although with such a structure as an arch dam, in which static conditions are so completely indeterminate, it would appear to be impossible to develop from theoretical considerations alone, formulas that will apply accurately to actual conditions.

* Discussion on the paper by F. A. Noetzli, Assoc. M. Am. Soc. C. E., continued from February, 1922, *Proceedings*.

† Asst. Engr., H. L. Haehl, San Francisco, Cal.

‡ Received by the Secretary, January 27th, 1922.

Real progress can only be made in the method of designing arch dams by securing more deflection measurements and other tests on existing structures, so that sufficient data may be collected to enable engineers to modify the theoretical formulas (in case such modification is found to be necessary) by certain empirical coefficients derived as the result of tests. The collection of such data could probably be best undertaken by some department of the State or Federal Government. Such observations would be assured of greater standardization in method and a greater uniformity of results.

The writer has not seen typical cross-sections of dams designed according to the author's principles. It is believed that such a presentation is essential to a clear understanding of the variations between his methods and the results obtained by the cylinder formula. It is understood that the cross-section of an arch dam will vary with the height and radius, but if the cross-section of some existing dam were shown, together with a design by the author for the same location, an interesting comparison could be made. The Barren Jack Dam or the Salmon Creek Dam which were shown, might be used in making such a comparison, and the writer hopes that the author will include some such presentation in his closing discussion.

William A. Miller,* Assoc. M. Am. Soc. C. E. (by letter).†—The writer has been much interested in Mr. Noetzli's further contribution to the literature on arch dams. Throughout, it is clear that one aim of the author is to place before the Profession a solution of the arch dam problem, as accurate as possible, without involving laborious algebraic or graphical operations. Although the writer has not especially considered the arch dam, he has studied the arch rib as a structural element from this same aspect, and he will contribute to the discussion of this paper by quoting the results of those portions of his investigations that are relative to the application of the arch rib as met with in the arch dam.

If the same assumptions are made in the derivation of Equation (17) as in arriving at Equation (10), then Equation (17) should read:

$$H_t = \frac{c\,T\,l\,E}{\int y^2 \frac{d\,L}{I} + \int \cos^2 \alpha \frac{d\,L}{A} + 3 \int \sin^2 \alpha \frac{d\,L}{A}} \qquad (23)$$

for the displacement of the point of application of H_t (that is, Point O' in Fig. 7 *b*, of Mr. Noetzli's paper, "Gravity and Arch Action in Curved Dams"),‡ due to temperature rise $= c\,T\,l$; and, due to H_t acting at O', the bending moment at $(x\,y) = M_x = -H\,y$, the axial force at $(x\,y) = N_x = H \cos \alpha$, and the shearing force at $(x\,y) = S_x = -H \sin \alpha$, giving the displacement O' due to M_x as,

$$\int M_x\,y \frac{d\,L}{E\,I} = -\int H_t\,y^2 \frac{d\,L}{E\,I},$$

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† Received by the Secretary, January 31st, 1922.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 27.

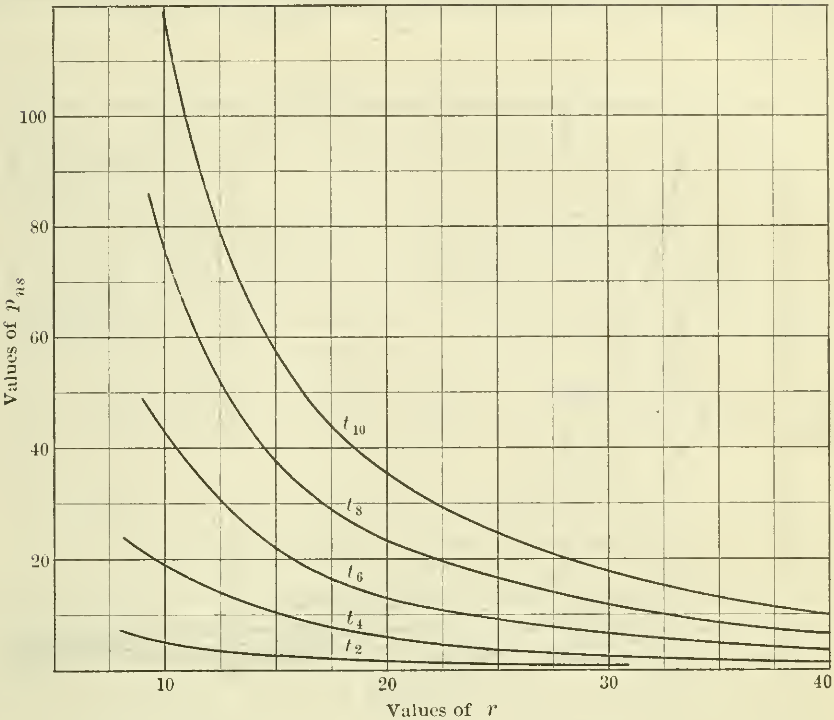
100
80
60
40
20
Values of p_{ns}
t_{10}
t_8
t_6
t_4
t_2
10
20
30
40
Values of r

FIG. 9.

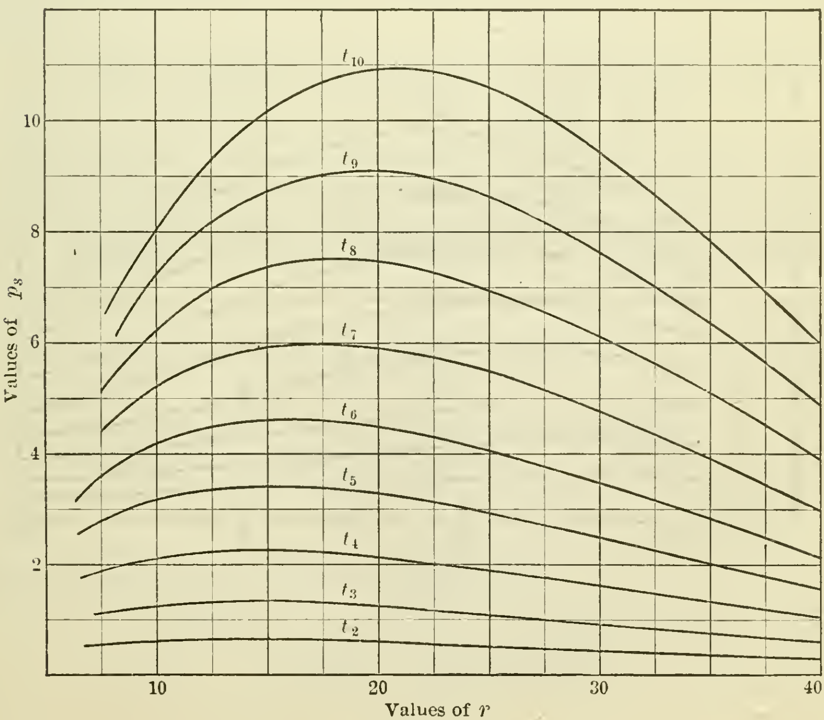
10
8
6
4
2
Values of p_s
t_{10}
t_9
t_8
t_7
t_6
t_5
t_4
t_3
t_2
10
20
30
40
Values of r

FIG. 10.

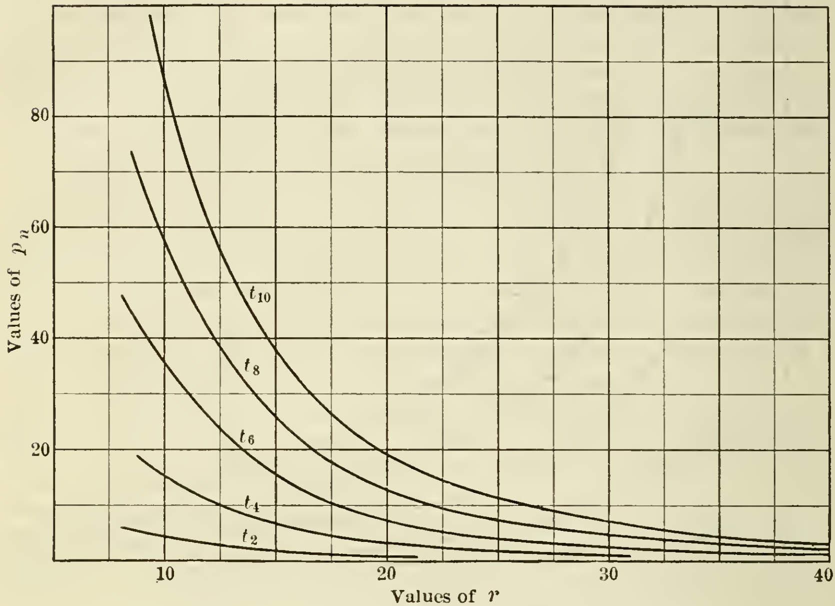
80
60
40
20
Values of p_n
t_{10}
t_8
t_6
t_4
t_2
10
20
30
40
Values of r

FIG. 11.

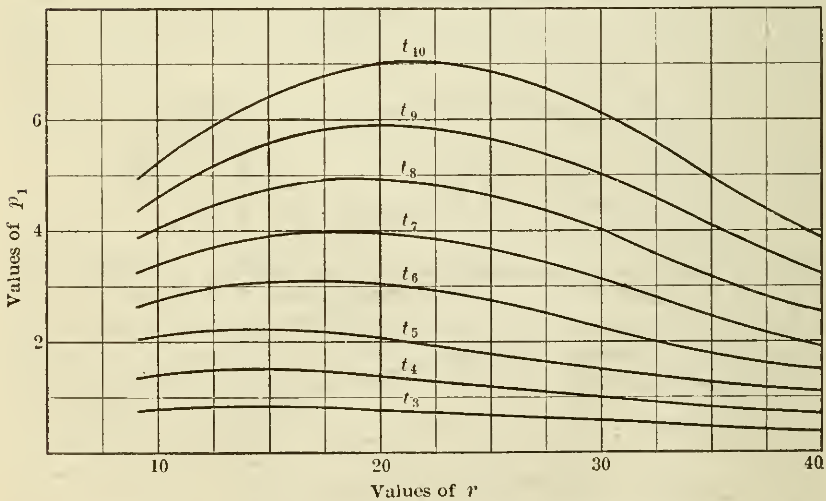
6
4
2
Values of p_1
t_{10}
t_9
t_8
t_7
t_6
t_5
t_4
t_3
10
20
30
40
Values of r

FIG. 12.

due to N_x as,

$$\int N_x \cos\alpha \frac{d\,L}{E\,A} = -\int H_t \cos^2\alpha \frac{d\,L}{E\,A},$$

and due to S_x as,

$$\frac{6}{5}\int S_x \sin\alpha \frac{d\,L}{G\,A} = -3\int H_t \sin^2\alpha \frac{d\,L}{E\,A},$$

where G is the rigidity modulus of the material, and taken here for concrete $= 0.4\,E$.

As the displacement of O' is zero,

$$c\,T\,l - \int H_t\,y^2 \frac{d\,L}{E\,I} - \int H_t \cos^2\alpha \frac{d\,L}{E\,A} - 3\int H_t \sin^2\alpha \frac{d\,L}{E\,A} = 0$$

or,

$$H_t = \frac{c\,T\,l}{\int y^2 \frac{d\,L}{E\,I} + \int \cos^2\alpha \frac{d\,L}{E\,A} + 3\int \sin^2\alpha \frac{d\,L}{E\,A}} \quad \text{.........(24)}$$

which for the constant, E, would take the form shown in Equation (23). It is to be noted that the denominator of Equation (24) is the displacement of O' due to unit load acting at O' and in the line of action of H_t; it is independent of the loading on the arch. The numerator is the displacement of O' due to the applied loading or, as in this particular case, temperature change, that is, if R is the displacement of O', due to any loading whatever, then the thrust is,

$$H = \frac{R}{\int y^2 \frac{d\,L}{E\,I} + \int \cos^2\alpha \frac{d\,L}{E\,A} + 3\int \sin^2\alpha \frac{d\,L}{E\,A}} \quad \text{........(25)}$$

It will be clear that the author's coefficients, k_t, are slightly in error. Fig. 12 shows the percentage error involved. The writer presents the foregoing, not with the idea of emphasizing small matters, but rather to make clear what follows. Considering the writer's Equation (25) to give the accurate value of the thrust, then,

$$H = \frac{R}{\int y^2 \frac{d\,L}{E\,I}} \quad \text{..........................(26)}$$

when deformations due to axial and shearing forces are neglected;

$$H = \frac{R}{\int y^2 \frac{d\,L}{E\,I} + \int \cos^2\alpha \frac{d\,L}{E\,A}} \quad \text{................(27)}$$

when only shearing force deformations are neglected;

$$H = \frac{R}{\int y^2 \frac{d\,L}{E\,I} + 3\int \sin^2\alpha \frac{d\,L}{E\,A}} \quad \text{................(28)}$$

neglecting only axial force deformations; and using the approximation in Mr. Noetzli's Equation (17),

$$H = \frac{R}{\int y^2 \frac{d\,L}{E\,I} + \int \frac{d\,L}{A}} \quad \text{.....................(29)}$$

For the rib as found in the arch dam the form in Equation (29) is equivalent to using Equation (25), but substituting unity for the coefficient, 3, of the third term of the denominator.

Let l = span;

r = the ratio, $\frac{\text{rise}}{\text{span}}$, expressed as a percentage;

p_{ns} = the percentage overestimate of the value of H using Equation (26);

p_s = the percentage overestimate of the value of H using Equation (27);

p_n = the percentage overestimate of the value of H using Equation (28);

p_1 = the percentage overestimate of the value of H using Equation (29).

Let t_1 denote a rib having a thickness equal to 1% of the span, and let t_2 denote a rib having a thickness equal to 2% of the span, and similarly, for other rib thickness; then Figs. 9, 10, 11, and 12 show values of p_{ns}, p_s, p_n, and p_1, respectively, for a series of ribs having values of r ranging from 10 to 40 and rib thicknesses varying from 2 to 10% of the span; the axes follow closely the axes used by Mr. Noetzli.

The diagrams call for little or no comment as they explain themselves. From Fig. 9, it is clear that flexural deformations alone should be considered, only for thin, high, rise ribs. Fig. 11 shows that the neglect of axial force deformations has little to commend it. Fig. 10 shows that including flexural and axial force deformations and neglecting those due to shearing forces gives percentage error in the value of thrust, almost constant for variation of rise, but increasing with increase of rib thickness. A study of Fig. 12, however, shows that a greater degree of accuracy is obtained by the use of Equation (29), which is the same as Mr. Noetzli's Equation (17). Not only does this expression give the closest approximation to the true value of the thrust, but the calculations are much simplified—a most desirable combination from the designer's viewpoint—for $\int \frac{d\,L}{A}$ replaces $\int \cos^2 \alpha \frac{d\,L}{A}$.

Chauncy Wernecke,* Assoc. M. Am. Soc. C. E. (by letter).†—The author's appeal to the Profession to assist in obtaining all possible data regarding deflections, temperature variation, and conditions of existing single arch dams should receive active support. Sufficient measurements on arch dams should go a long way to establish a more accurate method of design. Having such

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† Received by the Secretary, January 31st, 1922.

data, effective guidance could be given to further research with models. The degree to which the principle of similitude would apply, and the limiting size of models for reliable results, could be determined. Having thus established the reliability of models, the design of important structures might well be made from them, and the influence of the shape of the canyon could be determined in a most complete manner. The by-product value of such work would be considerable in any particular case. Such a method of design might at first seem costly, but in view of the possible saving in important structures, the extra expense would be well invested. Handling the problem in this manner would go far toward establishing faith in the economical arch dam.

There are two factors extraneous to scientific considerations in the design of an arch dam: First, a psychological factor resulting from lack of knowledge, and, second, a political factor injected when there are active opponents of the project in the community. The first consideration is partly basic to the second. Engineers lack knowledge as well as others. It is not to be expected that the knowledge and faith in the arch, as applied to bridges and buildings, will quickly transfer to a different use. It is to be expected that even for an engineer or architect whose knowledge of the arch is extensive and whose faith in it is great, that it will take some time for the same state of mind to form about the arch dam. For the average citizen, a proper faith in an arch dam would have to be carefully formed by well designed and honest propaganda. Otherwise, the second factor might cause considerable damage or delay to a project entertaining the use of such a structure. Such was the experience in 1904, with the Six-Mill Creek Arch Dam* for the water-works of Ithaca, N. Y., wherein the design afforded sufficient reason for a political filibuster to obtain public ownership of the water supply, and to reduce the dam from 90 ft. in height to 30 ft. The proportions of the Six-Mill Creek Dam were approved by a board of consulting engineers, but this had little effect.

It would seem advisable to initiate a co-ordinated research which might well begin with a thorough and impartial examination of arch dams. It is gratifying to note the interest in the subject, as measured by the space given it in the publications of the Society and other scientific journals.

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* *Transactions*, Am. Soc. C. E., Vol. LIII (1904), p. 183.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

THE CIRCULAR ARCH UNDER NORMAL LOADS

Discussion*

By Messrs. Fred A. Noetzli and William Cain.†

Fred A. Noetzli,‡ Assoc. M. Am. Soc. C. E. (by letter).§—This paper is a valuable contribution to the theory of arch dams, and it is to be hoped that tests will soon be made in order to determine to what extent the behavior of arch dams agrees with exact theory.

The study of the problem of arch dams, and with due consideration of the historical development of arch dam designs, has brought the writer to the conclusion that in the present state of knowledge with regard to modulus of elasticity, range of temperature, etc., of the dam material, it would be just as well to use, as a beginning, approximations for the sake of simplicity. More or less, successful attempts toward a correct solution have been made. Most of these calculations, however, had their merits buried, for the average reader, in higher mathematics, etc., and the new formulas, due to their complicated nature, were ignored by the busy designer.

The assumptions on which, at the present time, any theory of arch dams has to be based, still involve a considerable degree of uncertainty. This is, in the case of large arch dams, particularly true with regard to the modulus of elasticity, range of temperature, degree of shrinkage of concrete, "fixity" of the arches, swelling, lateral expansion (Poisson's ratio), secondary arch action, "wedge" action, etc., so that a high degree of accuracy in the formulas used is not of much value. Before extensive tests have been made, the modulus of elasticity can hardly be judged and its uniformity guaranteed within 20% of any assumption, and this is also true of the range of temperature, as well as the degree of shrinkage. Assuming for the other uncertainties involved another 20%, for all four assumptions together there is a probable error of,

$$\sqrt{20^2 - 20^2 - 20^2 - 20^2} = 40\%$$

* Discussion on the paper by William Cain, M. Am. Soc. C. E., continued from January, 1922, *Proceedings*.

† Author's closure.

‡ Chf. Engr., Beckman & Linden Eng. Corporation, San Francisco, Cal.

§ Received by the Secretary, February 7th, 1922.

which is probably conservative for thick dams. Consequently, if approximate formulas are within 20 to 25% of the theoretically correct values they may be considered, for the present, as sufficiently accurate as compared to the probable error of 40% in the assumptions.

Theoretically exact formulas, however, are desirable as long as they can be expressed in a simple form. Fortunately, the author's final equations go far toward this end, which makes his paper doubly valuable.

Professor Cain has also included in his investigation the thick and the flat arches, as they may occur in the lower parts of arch dams. Mr. Mensch* has expressed doubts as to the correctness of some of the deflection formulas and certain coefficients of Table 1. There is no question that by also considering the effect of shear, larger deflections will be found for short and thick arches than are obtained from the author's Equation (15).

However, it is rather questionable whether such thick and flat structures should be classified as arches. For instance, the author has calculated that for an arch with a radius of 135 ft., with a thickness of 40 ft., and a central angle of 40°, only 2½% of the load is supported by what is usually called arch action. The remainder of the load, or 97½%, is assumed, by the author, to be carried by beam action.

Mr. Mensch has shown why beam action cannot be relied on to carry the load. The writer wishes to point out why "secondary" arch action within the masonry may prevail in such a case. From Mr. Mensch's Fig. 5, it is seen that there is the possibility that within the large arch, a secondary arch is formed, approximately as shown by the dotted lines.† For the size of arch chosen by the author, a smaller arch with a radius of approximately 52 ft. and a thickness of 20 ft., may be inscribed. According to the cylinder formula, the stress in the large arch would be:

$$f_c = \frac{p\,r}{t} = p\,\frac{135}{40} = 3.37\,p$$

The stress in the small arch for the same load would be obtained at,

$$f'_c = \frac{p\,r}{\frac{t}{2}} = p\,\frac{52}{20} = 2.60\,p,$$

or even less than in the large arch. Thus, the small arch, due to the shorter radius, seems to be stronger than the large one. This reasoning indicates that secondary arch action will prevail in such a case. The size, shape, and stresses of the secondary arch can be determined by Castigliano's theory of least work. For the present purpose, it will be sufficient to indicate that arch formulas applied to such "arches" as shown in Fig. 5 may lead to erroneous conclusions. Giving due consideration to such limitations of the author's theory, it is seen that the discrepancies between his exact arch deflection formula and the writer's approximation‡ is comparatively small for all true arches as may occur in arch dams.

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 796.

† On this point, see also the writer's investigations on "vertical arching" in dams, *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 36.

‡ "Gravity and Arch Action in Curved Dams", *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 11.

It is of further interest to note that the author's method of calculating the arch deflection stresses, due to rib shortening and temperature changes, furnishes results that check almost exactly those obtained by the writer's method, using the coefficients from the curves of Fig. 4 and 5 of his recent paper "Deflections and Stresses in Arch Dams".* Consequently, the arch deflection stresses, calculated from measured deflections, will also be about the same if the same assumptions as to temperature, etc., are made.

It may not be amiss to warn against an indiscriminate application of the author's as well as the writer's "deflection stress" formulas. Those equations give reliable results for unreinforced arches only if, during the state of the deformation considered, the arches have no open tension cracks. If the calculations show tension in a dam to such a degree that the construction joints may open (for instance, at a tension of 50 lb. per sq. in.), these formulas can no more be applied directly. They then will indicate that the compression stresses are distributed unevenly over the arch.

Mr. Jakobsen† questions the correctness of a statement made by the writer,‡ that "in a fixed arch, the bending moments at the arch abutments resulting from the thrust, H, are twice as large as at the crown". This is no doubt due to a misunderstanding on the part of Mr. Jakobsen, inasmuch as the thrust, H, goes through the center of gravity of the arch,§ and this one is located, for arches to a central angle of 120°, at very nearly one-third of the rise from the crown and two-thirds of the rise from the abutments of the arch. Consequently, the lever arm for H, at the abutments, is twice as large as at the crown and, therefore, the bending moments also, due to H. Mr. Jakobsen apparently mistakes the moment given by the Equations (21) and (22), which include thrust and bending, with the moment from H (Fig. 4), which is due to temperature or rib shortening.

William Cain,‖ M. Am. Soc. C. E. (by letter).¶—To assist the practical engineer in the solution of "the circular arch under normal loads", Tables 1 and 2 have been much extended, and are given as Tables 4, 5, and 6. The coefficients in the starred rows were computed, the others being interpolated. In effecting the interpolation, curves were drawn for $\frac{t}{r}$ constant, and $2\phi_1$ variable, so that separate curves were drawn for $\frac{t}{r} = 0.00, 0.02, \ldots, 0.30$, in turn, from which the ordinates could be obtained for given values of $2\phi_1$. Where the curvature was appreciable, the results, for the interpolated values, are approximate, since they depend on how the curves are drawn between the points, as given by computation; but it is believed that the interpolated coefficients are sufficiently near the truth for use in practice. In fact, most of

* *Proceedings,* Am. Soc. C. E., October, 1921, pp. 281 and 282.

† *Proceedings,* Am. Soc. C. E., January, 1922, p. 92.

‡ *Proceedings,* Am. Soc. C. E., October, 1921, p. 266.

§ See, also, *Proceedings,* Am. Soc. C. E., October, 1921, p. 298.

‖ Prof. of Math., Univ. of North Carolina, Chapel Hill, N. C.

¶ Received by the Secretary, January 21st, 1922.

the interpolated values are practically exact. The regularity of the curves drawn to a large scale is the most convincing proof of the accuracy of the computations, although the formulas were changed to other but equivalent forms, for a few independent computations, as an additional check.

TABLE 4.—CIRCULAR ARCH FIXED AT ENDS, UNDER NORMAL LOADS.

Values of coefficient, c, in $\eta = c\left(\frac{p\ r^2}{E\ t}\right) = c\left(\frac{p'\ r\ r'}{E\ t}\right)$.

$2\phi_1$	$\frac{t}{r} = 0$	$\frac{t}{r} = 0.02$	$\frac{t}{r} = 0.06$	$\frac{t}{r} = 0.10$	$\frac{t}{r} = 0.15$	$\frac{t}{r} = 0.20$	$\frac{t}{r} = 0.25$	$\frac{t}{r} = 0.30$
*40°	1.877	1.708	0.994	0.542	0.287	0.173	0.115	0.081
45°	1.877	1.765	1.190	0.730	0.430	0.260	0.180	0.130
*50°	1.878	1.806	1.382	0.941	0.580	0.377	0.261	0.190
55°	1.879	1.825	1.510	1.120	0.750	0.515	0.365	0.270
*60°	1.881	1.845	1.606	1.277	0.911	0.651	0.477	0.360
65°	1.881	1.857	1.670	1.400	1.065	0.800	0.610	0.470
*70°	1.882	1.863	1.726	1.505	1.204	0.942	0.736	0.581
75°	1.883	1.867	1.760	1.580	1.325	1.070	0.865	0.700
*80°	1.884	1.873	1.791	1.648	1.425	1.198	0.995	0.825
85°	1.885	1.876	1.810	1.695	1.510	1.310	1.110	0.950
*90°	1.886	1.879	1.828	1.735	1.577	1.400	1.223	1.060
95°	1.887	1.881	1.840	1.765	1.630	1.480	1.320	1.160
*100°	1.889	1.884	1.851	1.789	1.679	1.546	1.404	1.262
110°	1.892	1.890	1.860	1.820	1.745	1.645	1.540	1.420
*120°	1.894	1.894	1.878	1.848	1.794	1.723	1.640	1.549
130°	1.897	1.897	1.885	1.865	1.830	1.770	1.710	1.640
*140°	1.901	1.900	1.893	1.878	1.850	1.812	1.766	1.713
160°	1.910	1.909	1.905	1.895	1.880	1.860	1.830	1.800
*180°	1.918	1.918	1.916	1.911	1.903	1.891	1.877	1.859

NOTE.—The starred rows were computed; the other rows were interpolated.

The curves for the coefficients of Table 4, for an arch "fixed at the ends", and for various values of $2\phi_1$ $\left(\frac{t}{r} \text{ varying}\right)$, are shown in Fig. 9.

On account of the small scale used, the interpolated values are not shown, especially as Table 4 will be generally consulted for any required coefficient.

Table 5 gives the deflection coefficients for an arch "hinged at the ends". No interpolated values are given, as, generally, it was thought that the results would only apply to the thinner arches.

TABLE 5.—CIRCULAR ARCH HINGED AT ENDS, UNDER NORMAL LOADS.

Values of coefficient, c, in $\eta = c\left(\frac{p\ r^2}{E\ t}\right) = c\left(\frac{p'\ r\ r'}{E\ t}\right)$

$2\phi_1$	$\frac{t}{r} = 0$	$\frac{t}{r} = 0.02$	$\frac{t}{r} = 0.06$	$\frac{t}{r} = 0.10$	$\frac{t}{r} = 0.15$	$\frac{t}{r} = 0.20$	$\frac{t}{r} = 0.25$	$\frac{t}{r} = 0.30$
*40°	1.566	1.541	1.363	1.108	0.811	0.590	0.437	0.332
*50°	1.568	1.557	1.478	1.342	1.138	0.938	0.773	0.625
*60°	1.570	1.565	1.518	1.453	1.331	1.190	1.047	0.914
*70°	1.573	1.570	1.549	1.509	1.436	1.344	1.243	1.138
*80°	1.576	1.574	1.562	1.538	1.494	1.436	1.367	1.292
*90°	1.579	1.578	1.568	1.556	1.528	1.490	1.444	1.392
*100°	1.584	1.583	1.578	1.569	1.550	1.525	1.494	1.458
*120°	1.593	1.593	1.590	1.586	1.578	1.566	1.551	1.533
*140°	1.605	1.605	1.604	1.602	1.597	1.592	1.584	1.574
*180°	1.637	1.637	1.636	1.636	1.634	1.632	1.630	1.627

NOTE.—All values were computed.

Table 6 gives the values of $\frac{2 \sin \phi_1}{D_0}$, to be used in the computation of either $(p\,r - P_0)$ or H (for temperature changes), for an arch "fixed at the ends", or one without hinges.

On account of the great variation in the coefficients, Mr. Jakobsen's plan* of using semi-logarithmic paper for the complete graph, was adopted. It is shown in Fig. 10.†

TABLE 6.

$$(p\,r - P_0) = \frac{2 \sin \phi_1}{D_0} \left(p\,r \frac{k^2}{r^2}\right)$$

Values of $\frac{2 \sin \phi_1}{D_0}$.

$2\,\phi_1$	$\frac{t}{r}$							
	0.00	0.02	0.06	0.10	0.15	0.20	0.25	0.30
*40°	3 021	2 750	1 600	872	461	278	184	130
42.5	2 380	2 200	1 380	806	442	273	181	129
*45	1 884	1 776	1 215	745	424	268	178	128
47.5	1 485	1 435	1 050	672	403	258	175	126
*50	1 235	1 188	909	618	381	248	171	124
52.5	1 010	980	780	558	357	237	166	122
*55	843	821	678	503	334	227	161	119
*60	595	584	508	404	288	205	150	113
65	445	440	386	320	246	182	137	105
*70	320	317	294	256	205	160	125	98
75	246	244	230	203	172	140	112	89
*80	187	186	180	163	141	119	98	81
85	150	149	142	130	117	101	86	72
*90	117	116	113	107	97	86	75	65
95	92	91	89	87	80	72	64	57
*100	76	76	74	72	67	62	56	50
105	64	64	63	62	58	54	48	44
110	54	54	53	52	50	47	42	39
115	44	44	43	42	41	39	36	34
*120	36	36	36	35	34	33	31	29
125	31	31	30	30	29	28	27	25
130	26	26	25	25	24	24	23	22
*140	19	19	19	19	19	18	18	17
150	15	15	15	15	14	14	14	14
160	12	12	12	11	11	11	10	10
170	9	9	9	9	8	8	8	8
*180	7	7	7	7	7	7	6	6

NOTE.—The starred rows were computed; the others were interpolated.

Mr. Noetzli has derived the formula:‡

$$H_t = k_t \frac{t^3}{h^2} E\,e\,t_0$$

* *Proceedings*, Am. Soc. C. E., January, 1922, p. 94.

† To include properly the interpolated values, Figs. 9 and 10 should be drawn to larger scales. A very satisfactory size for the engraved part of the semi-logarithmic paper is 12 in. square, with two logarithmic scales in the vertical direction. If the upper limit is marked 1 000, all values of Table 6 over 1 000, will not be represented; but such values are rarely needed, since they correspond to the smaller values of $\frac{t}{r}$ coupled with the smaller central angles.

‡ *Proceedings*, Am. Soc. C. E., October, 1921, p. 282.

for the thrust on the crown section, due to a temperature change of t_0 degrees, in which the influences of moment and tangential thrusts are considered. The coefficients, k_t, are to be taken from Fig. 5 of his paper.

The writer's formula for H, the thrust due to a temperature change, for an arch without hinges, can be expressed in the form last given, where k_t is replaced by,

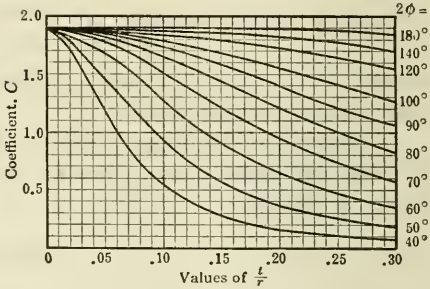

FIG. 9.

$$\frac{(1 - \cos \phi_1)^2}{12} \cdot \frac{2 \sin \phi_1}{D_0},$$

so that numerical values are readily computed by utilizing the values given in Table 6. This was done for a wide range of values of $\frac{t}{h}$ and $2\,\phi_1$. The numerical results were compared with the corresponding ones taken from Mr. Noetzli's Fig. 5 and were found to agree very well, thus affording a valuable check on the accuracy of the computations. Mr. Noetzli's Fig. 5 would have to be extended to cover the same range as the writer's Table 6 or Fig. 10; but, even then, it is compact and avoids the use of semi-logarithmic paper, so that there seems to be a practical advantage in expressing results in terms of $\frac{t}{h}$. A corresponding table should preferably give k_t to three significant figures. It will be recalled that $(p\,r - P_0)$, as computed by Equation (10) or by use of the coefficients given in Table 6, includes the influence of moments and tangential stress, the influence of shear being disregarded. It was originally assumed that the action of the right half of the arch on the crown section of the left half, was equivalent to a tangential thrust, P_o, and a couple, the moment of which was M_0. The value of this moment, as given by Equation (12), is,

$$M_0 = -\,(p\,r - P_0)\,E\,C,$$

where,

$$E\,C = r\left(1 - \frac{\sin \phi_1}{\phi_l}\right).$$

This moment is, therefore, always negative. The corresponding couple is left-handed, so that the original forces at the crown, Fig. 11 (*a*), can be replaced by the forces shown in Fig. 11 (*b*). On cancelling the two forces, $P_0 - P_0$, at C, there is left the single tangential force $(p\,r)$, acting to the left at C, and the single force $(p\,r - P_0)$, acting to the right at E, (Fig. 11 (*c*)); and these two forces are exactly equivalent to the original couple (the moment of which is M_0) and the tangential thrust, P_0, both acting at the crown.

It can be shown similarly, for an arch hinged at the ends, that the couple, the moment of which is M_o and the thrust, P_o, both acting at the crown sec-

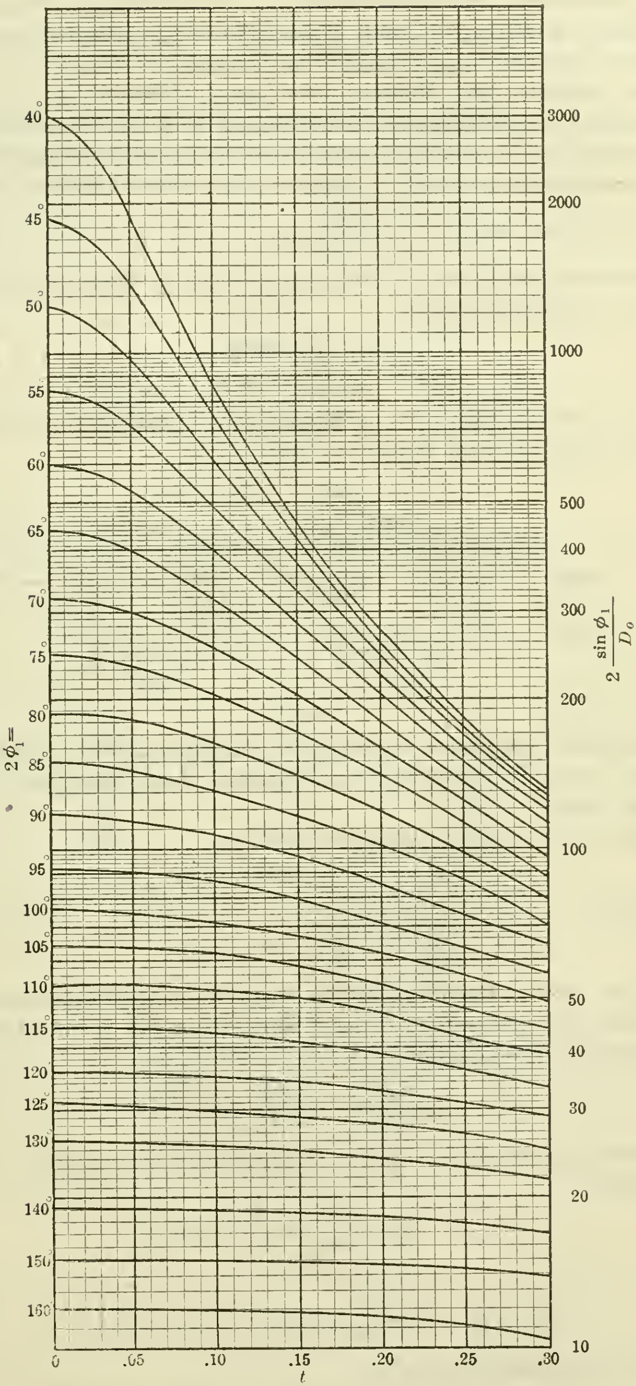
$2\phi_1 =$
40°
45°
50°
55°
60°
65°
70°
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
140°
150°
160°
3000
2000
1000
500
400
300
200
100
50
40
30
20
10
$2\frac{\sin\phi_1}{D_o}$
0
.05
.10
.15
.20
.25
.30
t

FIG. 10.

tion, can be replaced by a single force $(p\,r - P_0)$, acting to the right along the span line, $A\ B$, Fig. 11, and a single force $(p\,r)$, acting to the left, at the center of the crown, in a tangential direction.

Messrs. Jakobsen and Mensch* have called attention to the desirability of ascertaining the influence of shear, especially for thick arches and small central angles. Consequently, it has been thoroughly investigated, and some numerical results will shortly be given to show the decrease in moment due to shear for various values of $2\,\phi_1$ and ratio of $\frac{t}{r}$.

The formula for the elastic work due to shear by Bach (as quoted by Mr. Jakobsen), for the half arch, is,

$$2.88\,\frac{r}{2}\int_0^{\phi_1}\frac{S^2\,d\,\phi}{E\,t}$$

For an isotropic body (or one having equal elasticity in all directions), the coefficient 3.00 is used in place of 2.88.

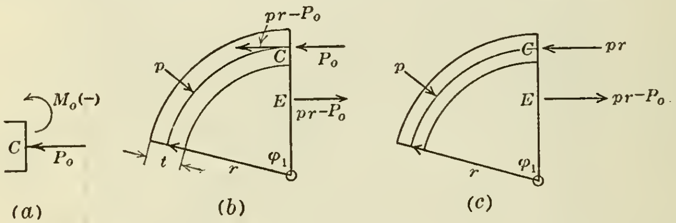

FIG. 11.

On adding the expression just given to the right member of Equation (5), the symbol, L, will then represent the internal elastic work due to moment, thrust, and shear.

The shear, S, as given by Equation (14), is,

$$S = (p\,r - P_0)_s \sin\phi.$$

Therefore,

$$\frac{\delta\,S}{\delta\,M_0} = 0;\ \frac{\delta\,S}{\delta\,P_0} = -\sin\phi.$$

Since the shear at the crown is zero, there are only two unknowns, M_0, P_0, to determine. By the method of least work, these can be found by elimination between the two equations:

$$\frac{\delta\,L}{\delta\,M_0} = 0,\ \frac{\delta\,L}{\delta\,P_0} = 0.$$

The solution proceeds exactly as before and is very simple. It leads to the formula,

$$(p\,r - P_0)_s = \frac{p\,r}{D_s}\,2\,\frac{k^2}{r^2}\,\phi_1\sin\phi_1,$$

where,

$$D_s = D + 2.88\,\frac{k^2}{r^2}\,\phi_1\left(\phi_1 - \frac{1}{2}\sin 2\,\phi_1\right),$$

D being given by Equation (11).

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 791.

The subscript, s, indicates that shear is included. The term involving 2.88 as a factor, expresses the influence of shear. When 2.88 is replaced by 3.0, as for an isotropic body, the value of D_s reduces to that given by Mr. Mensch.

When the term involving the factor 2.88 is omitted, the value of $(p\,r - P_0)$, as given by Equation (10), where shear was neglected, is derived.

Let the moment at the crown when shear is omitted be designated by M_0, and when shear is included, by M_s. Then, since Equations (7) and (12) hold, for the case when shear is included on replacing $(p\,r - P_0)$ by $(p\,r - P_0)_s$,

$$M_s = -(p\,r - P_0)_s\left(1 - \frac{\sin\phi_1}{\phi_1}\right),$$

$$M_0 = -(p\,r - P_0)\left(1 - \frac{\sin\phi_1}{\phi_1}\right).$$

therefore,

$$\frac{M_s}{M_0} = \frac{(p\,r - P_0)_s}{(p\,r - P_0)} = \frac{D}{D_s}.$$

The values of D and D_s were computed for various values of $2\,\phi_1$, t, and r, and their ratio, which is that of M_s to M_0, was inserted in Table 7.

TABLE 7.—ARCH FIXED AT ENDS. RATIO, $\frac{M_s}{M_0}$.

$2\,\phi_1$	r, in feet.	t, in feet.	$\frac{M_s}{M_0}$	Percentage of decrease due to shear.
40°	135	4	0.979	2.1
40°	135	20	0.909	9.1
40°	135	40	0.898	10.2
90°	300	30	0.952	4.8
120°	300	30	0.971	2.9
120°	135	4	0.997	0.3

The decrease in the moment at the crown due to shear seems to be negligible for central angles from 90° to 120°, and it only amounts to 10.2% for

$$2\,\phi_1 = 40° \text{ and } \frac{t}{r} = \frac{40}{135} = 0.297.$$

The derivation of the formula for deflection at the crown, when shear is included, involves long and tedious reductions, so that only a few steps will be given. For an arch without hinges, shear being included, by Equation (14),

$$S = (p\,r - P_0)_s \sin\phi$$

When the small radial force, w, is applied at the crown, the shear is,

$$S' = S + w\cos\phi \;\therefore\; \frac{\delta S'}{\delta w} = \cos\phi.$$

On adding the work due to shear and proceeding as on p. 292,* we derive,

$$\frac{E\,I}{r}\eta = \int_0^{\phi_1} M\,r\sin\phi\,d\,\phi + k^2\int_0^{\phi_1} P\sin\phi\,d\,\phi + 2.88\,k^2\int_0^{\phi_1} S\cos\phi\,d\,\phi.$$

* *Proceedings*, Am. Soc. C. E., October, 1921.

After substituting the values of M, P, and S, integrating and reducing, the value of $(p\,r = P_0)_s$ is eventually introduced, and the equation solved for the deflection, η, giving:

$$\eta = \frac{p\,r^2}{E\,t}\,\frac{(1-\cos\phi_1)\left\{\left(1+\frac{k^2}{r^2}\right)(\phi_1-\sin\phi_1)+2.88\,\frac{k^2}{r^2}\,(\phi_1+\sin\phi_1)\right\}}{\left(1+\frac{k^2}{r^2}\right)\left(\phi_1+\frac{1}{2}\sin 2\,\phi_1\right)-\frac{1-\cos 2\,\phi_1}{\phi_1}+2.88\,\frac{k^2}{r^2}\left(\phi_1-\frac{1}{2}\sin 2\,\phi_1\right)}$$

The influence of shear is represented by the terms containing the factor, 2.88, which, in this case, are found in both numerator and denominator.

As a numerical illustration of the influence of shear, take an arch for which, $2\,\phi_1 = 60°$, $t = 20$ ft., $r = 200$ ft.; whence, $\frac{t}{r} = 0.1$, $\frac{k^2}{r^2} = \frac{1}{12}\left(\frac{t}{r}\right)^2 = 0.0008333$. When shear is included, the formula gives

$$\eta = 1.2963\,\frac{pr^2}{E\,t}.$$

On omitting the terms containing 2.88 as a factor, the deflection, when shear is neglected, is found to be,

$$\eta = 1.2772\,\frac{pr^2}{Et},$$

or the influence of shear adds 1.5% to the deflection, in this case. From Table 1, for $2\,\phi_1 = 60°$, $\frac{t}{r} = 0.1$, there is found, $c = 1.277$, which agrees with the coefficient just found, as computed from an equivalent formula.

As to the accuracy of the formulas, since most of the steps have been given, it is easy for any one to verify them. The writer has carefully checked them, and some errors have been noted, due to errors in copying. On pages 291 and 295,* the second examples given, for $t = 40$ ft., $r = 135$ ft., should have the central angle, $2\,\phi_1 = 40°$ and not $2\,\phi_1 = 120°$. Among others, Mr. Mensch has properly called the writer's attention to these two errors.

As Mr. Mensch questions Equation (18), it seems proper to give some of the steps in the reduction, so that any one can easily verify the result. From Equations (16) and (4),

$$\frac{\delta\,M}{\delta\,P_0} = r\,(\cos\phi - \cos\phi_1);\quad \frac{\delta\,P}{\delta\,P_0} = \cos\phi.$$

On substituting these values in Equation (17), and also the values of M and P given by Equations (16) and (4), we derive,

$$r^2\,(P_0 - p\,r)\int_0^{\phi_1}(\cos\phi - \cos\phi_1)^2\,d\,\phi$$
$$+\,k^2\int_0^{\phi_1}\left\{(P_0 - p\,r)\cos^2\phi + p\,r\cos\phi\right\}d\,\phi = 0$$

On integrating and solving for $(p\,r - P_0)$, Equation (18) is readily derived. The denominator was first derived in another form and then reduced to the

* *Proceedings*, Am. Soc. C. E., October, 1921.

form given in Equation (18). It is instructive to compute the stresses of the flat arch, Fig. 5, and compare results with those given by Mr. Mensch for a straight beam fixed at the ends. The span, l, is 100 ft., the thickness, t, 40 ft., and the radius of the center line of the arch, as measured, on the drawing, is $r = 140$ ft.; consequently, $2\,\phi_1 = 41°\ 50'$, $\frac{t}{r} = 0.286$, and $k^2 = \frac{1}{12}(40^2)$. Also, from Table 6, $\frac{2 \sin \phi_1}{D_0} = 144$.

Mr. Mensch gives the pressure per square foot on the extrados as 10 000 lb.; therefore, the unit pressure on the center line is,

$$p = 10\,000 \times \frac{160}{140} = 11\,430 \text{ lb. per sq. ft.}$$

Equation (10), or its equivalent, gives,

$$(p\,r - P_0) = \frac{2 \sin \phi_1}{D_0}\ p\,\frac{k^2}{r} = 1\,567\,000;$$

whence, $P_0 = 33\,000$ lb. From Equation (12), $M_0 = -\ 4\,840\,000$ ft-lb. The unit stresses at extrados and intrados are found from the formula,

$$s = \frac{P}{t} \pm \frac{6\,M}{t^2},$$

to be, at the crown,

18 970 lb. per sq. ft. compression at extrados.
18 220 lb. per sq. ft. tension at intrados.

At the abutment, the moment, M_1, is found from Equation (13), for $\phi = \phi_1$, to be $M_1 = 9\,613\,000$ ft-lb.; and the tangential thrust, P_1, as computed from Equation (4), is $P_1 = 136\,000$ lb. The resulting unit stresses are;

39 400 lb. per sq. ft. compression at the intrados.
32 600 lb. per sq. ft. tension at the extrados.

For the straight beam, fixed at the ends, the extreme fiber stresses are, $\mp$ 15 000 lb. per sq. ft. at the crown, and $\mp$ 30 000 lb. per sq. ft. at the abutments.

The radial deflection at the crown of the arch is given by the formula:

$$\eta = c\ \frac{p\,r^2}{E\,t},$$

where c, by interpolation from Table 4, is found to be nearly, 0.115.

The deflection for the straight beam, subjected to the uniform loading, $p' = 10\,000$ lb. per sq. ft., can be found by the well known formula:

$$\frac{p'\,l^4}{32\,E\,t^3} = \frac{p}{E\,t}\ \frac{1}{32}\left(\frac{5\,r}{7}\right)^2\left(\frac{l}{t}\right)^2 = 0.10\ \frac{p'\,r^2}{E\,t};$$

whence,

$$\frac{\text{Deflection of arch}}{\text{Deflection of beam}} = \frac{0.115}{0.100}\ \frac{p}{p'} = 1.31$$

The computations have been given in full on the hypothesis that the concrete could stand the tension. Since this is not true, the arch would crack, about as

illustrated in Fig. 5.* The comments by Mr. Mensch relative to Figs. 6 and 7 are instructive, and the writer is glad to note that he endorses the reinforcing of arch dams and the tying of them in to the rock walls at the abutments. The writer does not think that "stresses can be found from deflection measurements of the arch", where the dam has vertical cracks, unless the deflection and temperature of the dam, at the time of closing of the dam, are recorded. He has made a reservation to that effect in discussing Mr. Noetzli's paper, and, in addition, has referred to the uncertainty relative to the modulus of elasticity.

The subject of inclined dams, commented on by Mr. Mensch, is important, as is known from a study of multiple-arch dams, and it will well repay careful investigation.

Mr. Jakobsen's discussion is not only interesting, but helpful. By taking the span constant and developing the formulas for moments, for an arch fixed at the ends, into series, and, ultimately, taking the limit, as the central angle approaches zero and the radius increases indefinitely, the arch approaches, as a limit, the straight beam with fixed ends, and the formulas for moments at crown and abutments are found to reduce to the corresponding moments for the straight beam at the center and ends. It is a "deadly" test that an exact formula can stand and one that approximate formulas generally fail to meet. It is a test easily made and will doubtless send to the scrap heap a number of formulas confidently proposed. All the formulas for moments and deflections of the writer's paper meet this test; and, to that extent, they may be said to be checked.

In the solution, just given, pertaining to the flat arch, Fig. 5, it was found that the stresses at the crown and abutments, as well as the crown deflection, approach the corresponding quantities for the straight beam. Further, the center of pressure at the crown section is $\frac{M_0}{P_0} = -146.7$ ft., from its center, on the extrados side. As the central angle tends toward zero, this center of pressure should recede indefinitely from the crown. To test this, the formula for P_0 was expanded in series, after r was expressed in terms of the span, l, and it was found to approach zero as ϕ_1 decreased indefinitely. Hence, since $M_0 = -\frac{1}{24} p l^2$, when $\phi_1 = 0$, therefore, $\frac{M_0}{P_0} = -\infty$. The same conclusion was reached for the arch hinged at the ends, where the bending moment at the crown, expressed in series, is,

$$M_0 = -p\,k^2 \frac{1 - \frac{1}{4}\phi_1^2 \ldots}{\frac{4}{15}\phi_1^2 \ldots + \frac{8\,k^2}{l^2}\left(1 - \frac{2}{3}\phi_1^2 \ldots\right)}$$

This reduces to $\left(-\frac{p\,l^2}{8}\right)$ for $\phi_1 = 0$, the moment at the center of a straight

* If the uncracked portion of the arch, Fig. 5, is supposed to constitute another arch. the dimensions (as roughly measured from the drawing) will be as follows: Radius, r, of center line = 50 ft., span of center line = 84 ft., thickness of arch, t = 18 ft. The central angle is, consequently, $2\,\phi_1 = 114° 18'$. On solving as before, it is found that there is no tension anywhere in this new arch, and that the greatest compression is 956 lb. per sq. in. at the intrados at the abutment. The large central angle accounts mainly for the great difference in the results.

beam, supported at the ends, when uniformly loaded. It has proved first, that $P_0 = 0$, when $\phi_1 = 0$, and, again, that $\frac{M_0}{P_0} = -\infty$ for $\phi_1 = 0$. The formulas for deflection afford equally satisfactory checks. Thus, substituting, $r = \frac{l}{2 \sin \phi_1}$ in Equation (15), for an arch fixed at the ends, and expanding,

$$\eta = \frac{p}{E\,t} \; \frac{\frac{l^2}{48}\left(1 + \frac{1}{3}\,\phi_1^2 \ldots\right) + k^2\,\phi_1^2\left(\frac{1}{12} + \ldots\right)}{\frac{2}{45}\,\phi_1^2 \ldots + \frac{8\,k^2}{l^2}\left(1 - \frac{2}{3}\,\phi_1^2 \ldots\right)},$$

which, for $\phi_1 = 0$, reduces to, $\frac{1}{32}\,\frac{p\,l^4}{E\,t^3}$, as for a straight beam, when shear is omitted. When shear is included, to compare with the usual formulas, replace the factor 2.88 by 3.00 in the formula for deflection given previously. To find the deflection due to shear only, use only the terms in the numerator having the factor 2.88, now replaced by 3.00. After expansion we derive.

$$\eta = \frac{\frac{3}{2}\,\frac{p\,k^2}{E\,t}\left(2 - \frac{1}{3}\,\phi_1^2 \ \ldots\right)}{\frac{2}{45}\,\phi_1^2 \ldots + \frac{8\,k^2}{l^2}\left(1 + \frac{1}{3}\,\phi_1^2 \ldots\right)},$$

which reduces, for $\phi_1 = 0$, to $\frac{3}{8}\,\frac{p\,l^2}{E\,t}$, the exact expression given in textbooks for a straight beam uniformly loaded.

The total deflection, when shear is included, for a straight beam, uniformly loaded and fixed at the ends is, thus,

$$\eta = \frac{p\,l^4}{32\,E\,t^3} + \frac{3}{8}\,\frac{p\,l^2}{E\,t} = \frac{p\,l^4}{32\,E\,t^3}\left[1 + 12\left(\frac{t}{l}\right)^2\right].$$

Apparently, the influence of shear, as $\frac{t}{l}$ increases, is more pronounced for the beam than for the arch.

The deflection of an arch hinged at the ends, is given by Equation (19). When this is expressed in terms of l and expanded, there is found,

$$\eta = \frac{p}{E\,t} \; \frac{\frac{1}{2}\left(1 - \frac{1}{12}\,\phi_1^2 \ldots\right)\left\{\frac{l^2}{4}\,\frac{\frac{5}{6}}{1 - \frac{1}{3}\,\phi_1^2} + \frac{1}{6}\,k^2\,\phi_1^2\left(1 - \frac{\phi_1^2}{20} \ldots\right)\right\}}{\frac{4}{15}\,\phi_1^2 + \frac{2}{3}\,\frac{t^2}{l^2}\left(1 - \frac{2}{3}\,\phi_1^2 \ldots\right)}$$

which, when $\phi_1 = 0$, reduces to,

$$\frac{5}{32}\,\frac{p\,l^4}{E\,t^3},$$

the known formula for a straight beam.

The value of $(p\,r - P_0)$ given by Equation (10) for fixed ends, and by Equation (18) for hinged ends, does not lead to known formulas as $\phi_1 \doteq 0$; but

on dividing by $(p\ r)$, putting in the right member, $r = \frac{l}{(2 \sin \phi_1)}$, and developing; then, as $\phi_1 \doteq 0$, $r \doteq \infty$, and for a straight beam, $P_0 = 0$, either equation gives, at the limit, $1 = 1$.

Finally, Equations (10), (15), (18), and (19) were deduced independently for $\phi_1 = 90$ degrees. The results checked with those given by these formulas for this angle.

The writer's paper was prepared for the practical engineer and every care was used to insure accuracy in both the formulas and the tables. They are believed to be accurate for the following reasons:

(1).—The formulas for temperature thrust, H_0, for either fixed or hinged ends, agree exactly with those deduced by Professor Church by a different procedure.

(2).—The quantity, D_0, appears in the denominators of the formulas for H, $(p\ r - P_0)$, M, and the deflection, η, for the arch with fixed ends. The expression designated by B appears, similarly, in the denominators of the formulas for H, $(p\ r - P_0)$, M, and η, for the arch with hinged ends.

(3).—As the central angle diminishes, the formulas for moments and deflections for an arch with a fixed span—whether with fixed or hinged ends—approach indefinitely the corresponding formulas for a straight beam, and the center of pressure at the crown recedes indefinitely.

(4).—As the central angle diminishes, the two members of the formulas for $(p\ r - P_0)$ approach an identity as a limit and P_0 tends to zero.

(5).—The formulas for $(p\ r - P_0)$ and for deflection, for both fixed and hinged ends, for the special case, $\phi_1 = 90°$, were derived independently. The results agreed with those given by the general formulas for $\phi_1 = 90$ degrees.

(6).—As to the tabular quantities, the regularity of the corresponding curves is the most convincing proof of their accuracy, though a few check computations were made by use of the formula, written in a different but equivalent form.

(7).—The coefficients of Table 2, when expressed in terms of $\frac{t}{h}$, are found to agree fairly well with those of Mr. Noetzli's Fig. 5*, thus affording a mutual check of results. Also, the coefficient of Mr. Noetzli's formula for deflection gives a rough check to many of the figures of Table 1. The computations of the quantities in Tables 1 and 2, and 4, 5, and 6, was a formidable task, but a systematic procedure lightened the labor and insured greater accuracy.

Mr. Mensch states that he "questions Equation (18) and some of the deflection formulas and many of the figures in Table 1". It is to be hoped that the reasons given in favor of their accuracy, may incline Mr. Mensch to check the various steps in the analysis; when, perhaps, all doubts as to their accuracy may be removed. When possible, it is desirable for the sake of scientific verity, that objections should be specific, so that the author may know what point to meet. In this way, the truth is more quickly attained.

* *Proceedings*, Am. Soc. C. E., October, 1921, p. 282.

Mr. Jakobsen seems to be under the impression that the expanded formulas may be best for computing moments. The writer has not found that to be the case for any of the formulas. After deriving the formulas for thrusts, moments, and deflections, they were at once expanded, in hope, that, by using the expanded form, numerical computation would be easier; but it was found that too many terms of the series would have to be taken to give sufficient accuracy and the method was abandoned.

It may seem superfluous to some that the writer has introduced into the discussion of curved dams the arch hinged at the ends. B. A. Smith,* M. Am. Soc. C. E., says:

"Unless extraordinary precautions are taken to fix in direction the ends of the arch, A and B, there will be deflections at these points which will correspond very nearly to the deflections due to no bending moment at A and B".

If there is sound rock on the hillsides at the ends of the successive horizontal arches, and these ends are fixed to the hillsides with the same care as is used with a reinforced concrete bridge, then any arch may be regarded as "fixed at the ends". It would be instructive if constructors would state the actual conditions. It is very doubtful if "extraordinary precautions" to fix the ends of the arches are generally taken, and a yielding abutment will invalidate any theory.

Some years ago, Professor Malverd A. Howe, M. Am. Soc. C. E., constructed an experimental reinforced concrete arch† to test the reliability of his summation formulas. The measurements were of such a refined character that H, V, and M at an abutment, could be accurately ascertained; but, at first, the measurements did not correspond with the computations for an arch fixed at the ends. Although the fixed abutment was of the usual design, it was eventually found to move; but the movement was so small that it was difficult to determine that it did move. However, when the abutment was thoroughly tied to the masonry walls of the house by rods, the larger errors were corrected, theory and observation were reconciled, and the results were regarded as very satisfactory.

For arched dams, the theory for hinged ends may only apply to very thin arches; but, if the thicker arches are only loosely connected with the hillsides, the moments, thrusts, and deflection may be intermediate in value to those for fixed and hinged ends.

It is well to state again what was emphasized on the first page of the writer's paper, that it is the part of the normal load on any horizontal arch, as determined by a correct analysis, that figures in all the computations. Thus, for water pressure, p' (except at one point) is not the unit pressure due to the depth of water at the arch on the extrados, but it is supposed to be the value given by Mr. Smith's analysis, or by Mr. Noetzli's tentative method, when applicable. We have then, $p =$ normal unit pressure on the center line of the arch $= \frac{p'\,r'}{r}$. The value of p at the crest, where the water pressure is nil, is often very large.‡

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 2030.

† See description of arch, apparatus, and measurements, with discussion of results, in *Railway Age Gazette*, March 26th, 1909.

‡ See the writer's discussions in *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), pp. 74, 88; also *Proceedings*, Am. Soc. C. E., January, 1922, p. 75.

Thus, for the Wooling Dam fixed at the base, with reservoir full, the greatest unit stress in a horizontal arch is at the crest, where $p' = 363$ lb. per sq. ft.; whereas, for the same dam, not fixed, but simply supported, at the base, the greatest unit stress is in an arch about 10 ft. below the crest, where $p' = 755$ lb. per sq. ft. The full water pressure at the base of the dam is 2 062 lb. per sq. ft., and it is seen that nothing like this pressure is exerted on any arch of the dam. Another caution refers to temperature stresses. The horizontal thrust, H, as deduced in this paper for a temperature change, pertains only to an arch perfectly free to move except for the restraints at the abutments. For the actual horizontal arch of a curved dam, the movement of the arch under a temperature change is resisted by the dam acting as a cantilever. Both influences must be considered for an arch regarded as a part of the dam. This is done in the notable paper of Mr. B. A. Smith on "Arched Dams"*, and also in the discussion by the writer of Mr. Noetzli's paper on "Gravity and Arch Action in Curved Dams".† The analysis is approximate and not as exact as that pertaining to water pressure.

On the basis of this analysis,‡ if p' = normal unit pressure on the extrados of the horizontal arch, considered from the water load and temperature change combined, and using Smith's formula for deflection, the total deflection, D, in feet, due to both causes, is,

$$D = \frac{3}{2} \frac{p' r'^2}{E t} - e r' t_0,$$

where

e = coefficient of expansion for 1° Fahr. = 0.000 0055, and

t_0 = change of temperature, in degrees, positive for a rise, negative for a fall of temperature.

By using the writer's more general expression for deflection, where the coefficients, c, may be taken from Table 4 or Table 5, according as the arch is regarded as fixed or hinged at the ends, we have,

$$D = c \frac{p r^2}{E t} - e r t_0,$$

where $p = \frac{p' r'}{r}$, is the normal pressure, in pounds per square foot, on the center line of the arch, r being the radius of that center line, as before.

On solving for $(p r)$,

$$(p r) = \frac{E t}{c r} (D + r e t_0),$$

t_0 being positive for a rise, and negative for a fall, in temperature. For an arch that is not cracked, if D is an observed deflection, the formula will give the value of $(p r)$, provided the arch is in compression. It will tend to give confidence in the results if, for observed deflections, computed deflections are sub-

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 2027.

† *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), pp. 79 and 90.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), pp. 81–87.

stituted, as for the thoroughly worked out case of the Wooling Dam, simply supported at the base.*

The computed values are as follows, for the crest: Water pressure: deflection = 0.362 in.; $T = 94\,600$ lb. per sq. ft.; temperature fall of 20° Fahr.; deflection = 0.270 in.; $T = 23\,170$ lb. per sq. ft. Both deflections are down stream and compression is exerted in both cases.

The combined deflection is thus $D = \frac{0.632}{12}$ ft., and the combined tangential thrust = 117 770 lb.

The computations were based on Smith's formula and value of $c = 1.50$; hence, to compare results properly, write r' for r, or, what amounts to the same thing, in the last formula, let $r = 135$ ft.; then, for $t = 2.2$ ft., $t_0 = -20°$, $E = 144 \times 2\,000\,000$ lb. per sq. ft., we derive,

$$(p\,r) = 118\,300 \text{ lb.},$$

which compares very well with $T = 117\,770$ lb., the thrust for the combined water pressure and temperature change.

In the discussion by the writer, previously cited, the formula for deflection, including the cases where T is either tension or compression, is discussed fully to prove that the last formula is general if attention is paid to the signs: D is positive when down stream and t_0 is as indicated. The applications to the Barren Jack Dam and the Salmon Creek Dam will show the method to follow when deflection observations are given, provided there are no cracks and the arch is in compression.

In case of vertical cracks, observations should be made of temperature and deflection at the time of the complete closing of the cracks. Then, similar observations are to be made at a subsequent period, and the difference in the temperatures will represent t_0 and the difference in the deflections will give the value of D to insert in the formulas. The uncertainty with regard to what value to assign to E, and the fact that the temperature of a dam is not uniform, particularly for thick dams, will render only an approximate solution in the general case. However, if the deflection observations are taken at the same time as the temperature, a large part of the uncertainty is eliminated; particularly if the air temperature, at the time of the two observations, has not varied for several days at the periods considered. From the value of $(p\,r)$, as computed for any dam, since r is known, the value of p can be formed. If this happens to be greater, or even nearly as large as, the unit water pressure at the base of the dam, the results should be rejected, for it would indicate, either that there were vertical cracks in the dam, that there was a lack of sufficient precision in the observations, or that the temperature was far from being uniform throughout the dam.

To complete the analysis, reference will now be made to Table 3, with the accompanying formula for the moment, M_0, at the crown of the horizontal arch considered:

$$M_0 = -a\left(\frac{E\,t^3}{r\,h}\right)\eta,$$

* The revised computation for this dam, using 8-place logarithmic tables, is given in the writer's discussion of Mr. Noetzli's paper on "The Relation Between Deflections and Stresses in Arch Dams", *Proceedings*, Am. Soc. C. E., October, 1921.

where the deflection, η, is positive for either water pressure or a fall of temperature, and negative for a rise of temperature.

Continuing the solution for the Wooling Dam, supposed not to be fixed at the base,

Let,

$$\eta_w = \text{deflection for water load} = \frac{0.362}{12 \text{ ft.}},$$

$$\eta_t = \text{deflection for } 20° \text{ fall of temperature} = \frac{0.270}{12 \text{ ft.}},$$

therefore,

$$\eta_w + \eta_t = D = \frac{0.632}{12 \text{ ft.}},$$

and,

$$\eta_w = 0.573\ D,\ \eta_t = 0.427\ D.$$

Suppose the very thin arch to be regarded as hinged at the ends; then, from Table 3, for $2\ \phi_1 = 120°$, $a = 0.083$ for water pressure, and $a = 0.121$ for temperature change, $t_0 = -20°$, therefore,

$$M_0 = -\frac{E\ t^3}{r\ h}[0.083\ \eta_w + 0.121\ \eta_t] = -\frac{E\ t^3}{r\ h} \times 0.1\ D.$$

On substituting, $E = 288\,000\,000$, $t = 2.2$, $r = 135$, $h = 67.5$, $D = 0.0527$, we derive,

$$M_0 = -1\,774 \text{ ft-lb.}$$

For a dam, for which η_w and η_t have not been computed, and only D is given by observation, the values of η_w and η_t, in terms of D, will have to be estimated. Some information for such an estimate can be had from the computed values of the Wooling Dam. From Equation (16), for the Wooling Dam, hinged at the ends, since $M = M_0$ when $y = h$,

$$(p\ r - P_0) = \frac{-M_0}{h} = \frac{1774}{67.5} = 30 \text{ lb.}$$

therefore,

$$P_0 = p\ r - 30 = 118\,300 \text{ lb. (say).}$$

The unit stresses, in pounds per square inch, at the crown, are:

390 compression at the extrados.

358 compression at the intrados.

To effect the solution for the arch fixed at the ends, the proper values of a must be taken from Table 3 and the value of M_0 computed as before. Then, from Equation (12), $(p\ r - P_0)$ can be found and the value of P_0 computed. If desired, the value of M at the abutment, can be found from Equation (13) by placing $\phi = \phi_1$.

The deflection lines for the Barron Jack Dam are given in Mr. Noetzli's paper on "Deflections and Stresses in Arch Dams",* the greatest deflection of 0.58 in. occurring on May 25th, 1909, at the crest, with reservoir full, the air temperature being 47° Fahr. On December 24th, 1908, with an empty reservoir, the temperature was 87° Fahr., and the deflection zero at the crest.

* *Proceedings*, Am. Soc. C. E., October, 1921, p. 271.

We have, therefore, $D = \frac{0.58}{12} = 0.0483$ ft., $t_0 = -40°$; and, using the dimensions given by Mr. Noetzli, $r = 79$ ft., $h = 24$ ft., $t = 2$ ft., whence $2\ \phi_1 = 91°\ 45'$.

Assuming this thin dam to be hinged at the ends, from Table 5,

$$c = 1.58,\ r\ e\ t_0 = -79 \times 0.000\,0055 \times 40 = -0.01738,$$
$$E = 144 \times 2\,500\,000 \text{ lb. per sq. ft.}$$

Therefore,

$$(p\ r) = \frac{E\ t}{c\ r}(D + r\ e\ t_0) = 0.0309\ \frac{E\ t}{c\ r} = 125\,800 \text{ lb.}$$

From Table 3, the coefficients to be used are 0.083 and 0.121, respectively, so that if it is assumed, arbitrarily,

$$\eta_w = 0.4\ D,\ \eta_t = 0.6\ D\ \therefore\ (0.083\ \eta_w + 0.121\ \eta_t) = 0.106\ D.$$

Therefore,

$$M_0 = -\frac{E\ t^3}{r\ h}(0.106\ D) = -7\,780 \text{ ft-lb.}$$

$$p\ r - P_0 = \frac{-M_0}{h} = 324\ \therefore\ P_0 = 125\,500 \text{ lb.}$$

The corresponding stresses at the crown of this arch are,

517 lb. per sq. in. compression at the extrados.

354 lb. per sq. in. compression at the intrados.

If the modulus, E, is reduced, the stresses will be reduced nearly as the ratio of the two moduli.

The deflection lines of May 25th, 1909, and of August 10th, 1909, for this dam, are crossed, which throws doubt on the accuracy of the observed deflections. Of course, if there were any cracks not entirely closed, at the time of the observation, when the reservoir was empty, which was probably the case, the results given are misleading and should be rejected.

With regard to the supposed flow or plasticity of concrete, and its varying modulus, it is to be hoped that a curved dam will be built so thoroughly reinforced and tied to the hillsides, that no cracks can form. Then, if precise observations of deflections and temperatures are taken, it should be possible, by the use of the given formulas, to obtain reliable results, provided the value of E is known. To determine that would require a complete solution of the dam, such as has been effected for the Wooling Dam, so that the value of p for any horizontal arch is known; then on solving the equation,

$$D = c\ \frac{p\ r^2}{E\ t} - e\ r\ t_0,$$

for E, its numerical value could be ascertained. It is preferable, of course, to eliminate temperature change by using observations for deflections, for different heights of water, when the dam is at the same temperature.

It has been stated that the solution of Mr. B. A. Smith,* pertains strictly to thin dams. This is evident from the derivation of Equation (1) of the paper cited,

$$\frac{d\ F}{d\ z} - \frac{T}{R} + p = 0 \qquad (1).$$

* *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 2027.

When the shear, F, between the successive horizontal arches, is ignored, this reduces to the ordinary cylinder formula, $T = p\ R$, which is only true for the linear arch, or practically true for a thin arch. In a number of examples of thick arches with small central angles, discussed by the writer, as the arch represented by Fig. 5, it has been seen that the cylinder formula is totally inapplicable.

As such thick arches, with small central angles, only occur near the base in a V-shaped valley, it is possible that Mr. Smith's method may lead to practical results. No other rational method has as yet been proposed for the dam not fixed at the base. For the dam fixed at the base, the tentative method will apply, since the coefficients, c, of Tables 4 and 5 take account of the deflections, as $\frac{t}{r}$ and the central angle vary. This is true if the shear between the horizontal arches can be practically ignored, which can be done, as proved by the writer, for thin dams, such as the Wooling Dam.

The subject is a very complicated one and the writer returns sincere thanks to those who have so kindly assisted in discussing it.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

A REVIEW OF IMPORTANT DEVELOPMENTS IN THE SCIENCE OF CADASTRAL RESURVEYS AS EXECUTED BY THE UNITED STATES GOVERNMENT, WITH ETHICAL DISCUSSION THEREOF

Discussion*

By Messrs. H. B. Patten and J. F. Le Baron.

H. B. Patten,† M. Am. Soc. C. E. (by letter).‡—The resurvey of the public lands of the United States presents an interesting development. It is fortunate that the author has seen fit to call the attention of the Engineering Profession at large to the results of the evolution exhibited in the work of the cadastral engineer engaged in the resurveys.

As in all other branches of science, that of cadastral engineering, when applied to resurveys, has been a gradual and extended development. The first efforts in light of present-day practice appear to be crude. A great advance was made in the public survey when the Government changed from the contract system to the direct method of executing the work. The wisdom of the change has been fully justified in the results obtained in a period of more than eleven years. One of the advantages was in providing the opportunity for more deliberate effort in field work, notwithstanding the increased expense.

It may be of interest to the Profession to call attention to the general progress of resurveys in Wyoming. Among the earliest attempts at resurveys were those authorized in 1891, under Contract 238, in the Valley of the North Platte River in what is now Converse County. Some of the cardinal principles of the resurvey were overlooked at that time, and the work led to so much confusion that it was discontinued. Recently, these lands have been resurveyed, however, in conformity with the most up-to-date practice.

Later, in 1899, resurveys were again undertaken in Wyoming of lands along Fontenelle Creek in Lincoln County. This work conformed to the

* Discussion of the paper by Howard Richards Farnsworth, Assoc. M. Am. Soc. C. E., continued from February, 1922, *Proceedings*.

† Washington, D. C.

‡ Received by the Secretary, February 14th, 1922.

essential principles necessary for the preservation of the rights of the settlers, and fairly acceptable results were obtained.

Owing to the large extent of inexcusable error and fraud in the original surveys of the early Eighties, Congress by Act approved May 29th, 1908, authorized the resurvey of 371 townships, nearly 7 800 000 acres of land, in various parts of the State. Thus far, only a part of this work has been accomplished.

It has been suggested at times that topographic features should be determined in connection with cadastral surveys and that only one party in the field should be charged with the execution of all this work at the same time; but the fact that the requirements of the two types of surveys vary in many particulars seems to be overlooked by some, so that to carry both systems at the same time clearly increases the expense and delays the ultimate accomplishment.

A radical difference which is not always appreciated, exists between the field and office work necessary to depict the physical characteristics of the country and the intricate work involved in the proper establishment of the division and subdivision lines of the public survey called for in the rectangular system, especially in the re-establishment, restoration, and fixation of section and property lines dependent on the former position of lost or obliterated corners.

In the latter case, there is desired the correct location of the legal position of the section corners and lines as a basis for the proper adjudication of conflicting claims.

J. F. Le Baron,* M. Am. Soc. C. E. (by letter).†—It is refreshing to know, even at this late date, that the surveys of the public lands are now being made by real surveyors, and are really made and not "fudged", or scamped. Every one, particularly the people in the West, know the shameful history of these surveys.

The basic plan of the surveys was conceived in wisdom and sound technique, but the method of administration was a disgrace to the nation, and has resulted in untold confusion and needless litigation and has foisted on an unsuspecting and innocent public about 6 000 000 homesteads with insecure and faulty titles, and, too often, no titles whatever, owing to erroneous delineation of boundaries and, consequently, erroneous areas of the sections and subdivisions into which the land was divided.

This era of mal-administration is past, and the members of the Engineering Profession can obtain some comfort from the thought that by devoting themselves to the rectification of these errors, they can do much to assist the unfortunate victims of a pernicious system.

About forty years ago, while building a railroad in Florida, the writer was in a locality where land had rapidly appreciated in value, and where the public land surveys, which had been made about thirty or forty years before, were in the usual condition of uncertainty and inaccuracy. The writer spent some of his spare time to trying to re-locate last corners and to decide the

* Cons. Engr., Essex, Mass.

† Received by the Secretary, Feb. 15th, 1922.

location of many disputed lines between valuable orange groves. He was appointed a U. S. Deputy and also U. S. Mineral Surveyor to survey some military reservations and phosphate mining claims.

Later, he removed to Jacksonville, Fla., and was engaged to establish the lines of the five old Spanish grants on which that city is built. About 50% of these grants were, at that time, covered with commercial and residential buildings. The corners of all these grants had long ago been destroyed by the growth of the city, but all the land titles in the city were based on these grant lines and corners. It was no easy task, but after nearly a year's work, they were re-located satisfactorily.

In recovering several of the old corners outside of the compactly built up city (Jacksonville), the tap-roots of the hard pine witness trees were found. The writer has often found old well blazed section lines leading to a point 20 to 75 ft. from the established corner, which corner might be also identified by other blazed lines leading to it from other directions and by well marked and identified witness trees. Generally speaking, the distances from the corner to the witness trees were not measured, but were either paced or estimated, although the courses given in the original field notes were generally correct. Lengths of section lines generally overrun 10 to 30 links, making the areas of the sections larger than the acreage given on the official plats. It would be interesting to know how many acres of land the Government has lost by this error in the whole of the public lands. It is safe to say it would be up in the millions of acres.

The fraudulent surveying of shore lines of rivers and other bodies of water has worked serious harm. Intending settlers or purchasers, deceived by the officially certified plats furnished by the Government, have selected lands, paid for them, and often settled on them, only to discover the shore line mislocated and possibly a bay or other body of water where the Government plats showed high land, and their acreage thus reduced, oftentimes, 10 to 20 acres.

In 1876, the surveys had been completed in ten States and Territories, and were in progress in twenty others. They are now practically completed, except in Alaska and Utah, and resurveys in some States. Omitting Alaska, the arable acreage of which is unknown, there remains 19 000 000 acres to be surveyed in Utah.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

THE FLOOD OF SEPTEMBER, 1921, AT SAN ANTONIO, TEXAS

Discussion*

By Messrs. Allen Hazen and Edgar Jadwin.

Allen Hazen,† M. Am. Soc. C. E. (by letter).‡—This paper is a description of a most interesting flood. The writer had occasion to visit San Antonio shortly after the flood, and he read the paper carefully in connection with his own observations and commends the author for a concise and accurate statement.

In this case, the reason for anticipating a large flood had been pointed out professionally to the city by Messrs. Metcalf and Eddy, who had studied the conditions only a short time before. The lesson to be learned from this and other floods is that growing cities must give more attention to flood channels that are being closed by bridges, buildings, and encroachments of all kinds.

The San Antonio flood and other floods sometimes go so far beyond previous experience as to suggest that there is no law of flood frequencies that governs. The writer does not believe that this view can be supported.

Engineers are learning more every year about the laws that govern the frequency of floods. Each new record helps. It may be expected that the continuous records of gauging stations will ultimately be more useful in establishing these laws than records of destructive floods that occur now and then where there is no continuous gauging. These extreme floods serve to support and emphasize the conclusions that may be deduced from the study of records from regular gauging stations that much larger floods are to be logically anticipated at infrequent intervals.

There is a flood to be expected each year. There is a greater flood to be expected on an average once in 10 years, and there is a still greater flood to be expected on an average once in 100 years, and so on, and with innumerable intermediate steps. The chance is only one-hundredth of 1% that the

* Discussion on the paper by C. Terrell Bartlett, M. Am. Soc. C. E., continued from December, 1921, *Proceedings*.

† Cons. Engr. (Hazen, Whipple and Fuller), New York City.

‡ Received by the Secretary, January 20th, 1922.

10 000-year flood will occur at any one place in any one year, but when the whole country is considered, some cities will suffer from such floods with a frequency well within the experience of human life, and the possibility of their occurrence at any place in any year must be taken into account.

The writer hopes that some day there will be evolved a much better basis for estimating these probabilities and for determining how much may be done in preventing them without, on the other hand, going to unreasonable extremes.

Edgar Jadwin,* Esq. (by letter).†—This paper contains an excellent account of the San Antonio storm and its relation to the general terrain, as well as to the local conditions, particularly as it was written soon after the storm and probably before all possible data could be obtained and digested. The records of the U. S. Engineer Office at Fort Sam Houston agree substantially with those presented by the author and only a few slight differences are worthy of mention.

Some slight differences in data were observed, regarding the amount of flow in the various streams, which are submitted here, as they show a slightly more constant maximum discharge per square mile. The maximum discharge from the Olmos, as computed by the office of the Engineer, Eighth Corps Area, was 25 000 sec-ft., which would give an estimated flow of this basin of about 930 sec-ft. per sq. mile. For Apache Creek, an estimate fixed the maximum discharge at 22 560. or 947 sec-ft. per sq. mile. On the Martinez-Alazan, the maximum flow estimated was 24 000 sec-ft., or 1 223 per sq. mile.

The flood was the result of a rain storm, of which the zone of greatest precipitation lay easterly and westerly across the head-waters of these streams. In San Antonio the flood peaks of the Alazan and Apache Creeks arrived at different times. The peaks of both had passed before the slower gathering flood from the San Antonio River arrived. Had a combination of circumstances made the crests of the various creeks arrive simultaneously, the damage to the lower part of the city, undoubtedly, would have been much greater. As it was, the river, in the southernmost part of the city, overflowed its banks only slightly.

Since his paper was written, the committee of engineers which Mr. Bartlett mentions, has recommended methods to prevent a future recurrence of these floods. This plan provides that the channels of the San Pedro, Alazan, and Apache Creeks be widened, deepened, and straightened, that the grades along the banks be generally raised, and that a strip of varying width, on these streams be reserved through the town. This part of the city is not nearly as thickly settled and the land is less valuable than that in the valley of the San Antonio.

On the San Antonio, where the land is too valuable to allow purchase of a strip wide enough to carry the full flood flow, the Committee recommends a straightening of the river by the elimination of several large bends within the city and a slight deepening and widening of the channel. This channel now has a capacity of approximately 6 000 sec-ft. in its improved parts, and

* Col., Corps of Engrs., U. S. A., Fort Sam Houston, Tex.

† Received by the Secretary, February 27th, 1922.

will have its capacity increased to 15 000 sec-ft. In addition, the Committee recommends constructing a concrete retention dam to form a dry reservoir at a point near the mouth of the Olmos and about 2 000 ft. north of the northern boundary of the city, where borings indicate a good foundation. This dam is to be provided with permanent openings to allow the discharge of 6 000 sec-ft., retaining all peak water in excess of that quantity until the channel can carry it. The estimated cost of this construction is $5 500 000.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

THE AREA OF WATER SURFACE AS A CONTROLLING FACTOR IN THE CONDITION OF POLLUTED HARBOR WATERS

Discussion*

By Messrs. W. C. Purdy, Allen Hazen, and Warren R. Borst.

W. C. Purdy,† Esq. (by letter).‡—This paper, dealing with re-oxygenation of the polluted waters of New York Harbor, is of much interest, but sufficient controlled observations do not seem to be available on which to base definite conclusions. Other factors than wind action may be responsible for great fluctuations in the oxygen content of the harbor waters. The author mentions three sources of oxygen, namely, the sea water, water of tributary streams, and the atmosphere. Granting that oxygen undoubtedly does accrue to the harbor waters from all these sources, the writer, who is a biologist, desires to call attention to another probable source.

The author makes no mention of the presence—or the absence—of aquatic plants in the waters studied. Unless the situation is totally different from that which is ordinarily found along the seaboard, especially in the more shallow waters, there is, in all probability, a considerable growth of various algæ or "sea weeds", green, brown, or red in color, also of eel-grass, and of *Ceratophyllum* or "fish-moss", commonly used in aquaria. Finally, it is practically certain that diatoms and other of the microscopic plants are present.

Practically all these plants give off oxygen as a waste product of their metabolism in the presence of sunlight. This oxygen, which is produced under water, is naturally taken up largely by the surrounding water, until, in some cases, the latter becomes supersaturated with oxygen. It would be interesting to have a detailed record of the amount of sunlight exposure on such days when large increases in oxygen content was noted between morning and afternoon observations. A close correlation of increase of dissolved oxygen and sunlight available would no doubt be observed.

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* This discussion (of the paper by Richard H. Gould, Assoc. M. Am. Soc. C. E., published in December, 1921, *Proceedings*, but not presented at any meeting of the Society), is printed in *Proceedings*, in order that the views expressed may be brought before all members for further discussion.

† Special Plankton Expert, U. S. Public Health Service, Cincinnati, Ohio.

‡ Received by the Secretary, February 10th, 1922.

The net result of this production of oxygen by submerged plants is sometimes very noticeable, not only in the oxygen content of the water, but also in the evident increase in the capacity of this water to dispose of organic matter. In the investigation of the Potomac River,* it was found that aquatic plants were largely responsible for the production of oxygen, sufficient to assist materially in the reduction of the 60 000 000 gal. of sewage emptied daily into the river by the City of Washington.

In an unpublished study of the effect of diatoms (a plant of microscopic size) on the oxygen content of water in the Ohio River, it was found that when diatoms were present to the extent of about 68 parts per million (by volume) per cubic centimeter of water, the oxygen content increased considerably more than in the same water from which the diatoms had just been removed by filtering. A similar increase was noted over the oxygen content of a third sample of the same water which contained the diatoms, but was kept in darkness, under which conditions the plants could not function properly.

It is hoped that if plants—either microscopic or large—are present in a given water, these organisms will be credited with the oxygen that they must necessarily contribute to the water. It would seem illogical to take account of the layer of atmosphere above the water body, only one-fifth of which is oxygen, and ignore the visible producers of practically pure oxygen, which may, to a great extent, carpet the bottom in shallow waters, and those invisible but numerous oxygen producers, the microscopic algæ, which are usually present unless the water is too deep or too turbid for the light to penetrate.

Allen Hazen,† M. Am. Soc. C. E. (by letter).‡—In drawing attention to the re-aeration of water in New York Harbor by the air, especially under the influence of wind action, the author has rendered a great service. This is an important matter, and sufficient attention has not been given to it in past studies of harbor conditions.

The water in the harbor receives the sewage of the city. This sewage contains a large amount of organic matter which is decomposing and oxidizing. Oxygen is required in order that these processes may go on. If there is enough oxygen, the processes are comparatively unobjectionable and free from the production of nuisance; if, however, the supply of oxygen at any point is overtaxed, other processes set in, that are offensive. The presence or absence of oxygen corresponds closely with conditions that are inoffensive or offensive, and it is essential, therefore, for the comfort of the communities about the harbor, that there should be enough oxygen in the water.

The air is 21% oxygen. Water dissolves only about 2% of its volume of air. Ordinarily, the water coming down the Hudson River and the sea water coming in from the ocean are saturated, or nearly saturated, with oxygen.

The quantity of water in each tide is definitely known, and the new water forming a part of it can be computed approximately. The computation is

* U. S. Public Health Service, Hygienic Laboratory *Bulletin No. 104*, Supt. of Documents, Washington, D. C.

† Cons. Engr. (Hazen, Whipple, and Fuller), New York City.

‡ Received by the Secretary, February 16th, 1922.

approximate, because the percentage of new water in the water coming back with the tidal flow must be estimated, and chemical analysis furnishes a tolerably definite basis for this estimate. The new water entering the harbor from the sea and from the river, estimated in this way, is equal to a continuous flow of about 76 000 cu. ft. per sec.* When the rivers are in flood, the quantity of fresh water entering the harbor is greatly increased and tends to take the place of and keep out an equal volume of sea water. When the flows of the rivers are low, the sea water enters in full quantity, and almost the entire mass of water in the harbor is composed of it. As an annual average, approximately one-third of the new water is from the rivers and two-thirds from the ocean. River water carries somewhat more oxygen per unit than sea water, and cold water in winter carries more than warmer water in summer.

Without attempting refinements, the average quantity of oxygen carried by the new water, at an average temperature of 50°, is about 89 lb. per 1 000 000 gal. This is increased to 110 lb. in winter and decreased to about 65 lb. at 68°, which may be taken as summer temperature for sea water entering the harbor.

New water at the rate of 76 000 cu. ft. per sec. is equivalent to 49 200 000 000 gal. daily. The average quantity of dissolved oxygen carried by this new water is approximately 4 400 000 lb. per day as an annual average. The summer quantity amounts to 3 200 000 lb. per day.

The demand for oxygen is most rapid in summer, because oxidation goes on more rapidly then, and changes take place in the harbor which at other seasons are completed at remote places where other supplies of oxygen are available. The summer period, therefore, is the critical time, and summer quantities only need be considered.

The summer quantity estimated, is equal to 0.4 lb. daily (or 180 grammes) for each person now living in the Metropolitan District, and is sufficient to oxidize the sewage of a much larger population. In order to utilize it to its fullest extent, however, it is necessary that the sewage be completely mixed with all of it. Such a distribution is not obtained and is not possible. There are places of local concentration of sewage and, at these places, the supply of oxygen is drawn lower than elsewhere.

The secondary source of oxygen, as the author has pointed out, is the atmosphere; he thinks this is the greatest source.

When the water in the harbor is saturated with oxygen, there is no absorption of oxygen from the air by it. As soon as the water in any part of the harbor becomes less than saturated, the absorption of oxygen from the air begins, and the oxygen thus absorbed adds to the supply otherwise available. The absorption of oxygen from the air by water, other things being equal, is directly proportional to the amount of reduction below the saturation point. If twice as much oxygen is used by the sewage in any locality, there will be twice the degree of depletion in that locality, and, with it, the rate of absorption from the air will be doubled.

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* *Transactions*, Am. Soc. C. E., Vol. LXXVI (1913), p. 2094.

Oxygen derived from the air, therefore, is greatest in amount at exactly those places where the need of it is greatest; and for this reason the value of the oxygen derived from the air is of the greatest value in keeping the harbor water sweet.

Some early studies on oxygen absorption started with the assumption that oxygen absorbed by the surface layer of water must be carried to lower layers of diffusion. If this was the case, the slowness of the diffusion process would limit the amount of oxygen that could be absorbed in this way. Fortunately, there are other means of distributing the oxygen. The tides keep the water in the harbor always in motion, and there is a mixing that is many times more powerful than diffusion in carrying the re-aerated water below the surface, and in bringing water that needs aeration from below to the surface, where it alone can be aerated. This movement due to tidal action is always going on.

Wind action is still more potent when available, but is intermittent in its action. A heavy wind brings all the water into contact with air, and results in a great increase in the rate of absorption. This increase is fairly comparable to that which takes place when a bellows is applied to a bed of coals.

The absorption of oxygen, other things being equal, is greater in shallow parts of the Bay, where the surface exposed, in proportion to volume, is greater than elsewhere, as, for instance, in Newark Bay.

How far the absorption of oxygen from the air by the exposed surface of the harbor will add to its capacity to receive and dispose of sewage, is not known. The matter is progressive; as the need of oxygen in any part of the harbor increases, the rate of absorption increases with it. Only the future, with greater populations, will disclose the limit.

In the meantime, such studies as that presented by the author, bring to notice these important fundamental actions and will tend to a better understanding of what is taking place.

WARREN R. BORST,* ESQ. (by letter).†—The author's observations on the fluctuation of dissolved oxygen values in the Arthur Kill, at Elizabeth, N. J., are of special value and interest to the Borough of Richmond, especially so, as the observations made in waters adjacent to Staten Island shores seem to confirm the investigations with regard to the absorption of oxygen made at the West Brighton Sewage Experiment Station, in 1916, under direction of the President of the Borough of Richmond. However, it would not seem possible to determine a quantitative relation between wind velocities and dissolved oxygen content, unless it was possible to determine the depth of the influence of wave action caused by the wind. From past experience and data at hand, it would seem that the depth the oscillation penetrates below the surface of the water depends on the violence with which the surface of the water is disturbed.

The experimental work in the absorption of oxygen at the West Brighton Sewage Experimental Plant verified, in a large tank, the results which Mr. Adeney found to be true in glass tubes, namely, that the oxygen gravitated

* Asst. Engr., Borough of Richmond, West New Brighton, N. Y.

† Received by the Secretary, February 16th, 1922.

downward so rapidly that it was impossible to determine the rate, and, for practical purposes, in the writer's observations, was considered instantaneous for the full depth of 5½ ft. The velocity with which this diffusion or gravitation of oxygen takes place will be better appreciated by the following statement taken from the Fifth Report of the Royal Commission on Sewage Disposal of Great Britain:

"Hüfner in his work on the diffusion coefficients of gases in water met with the phenomenon of the comparatively rapid downward passage or streaming of the dissolved gas, and, in consequence, found that it was impossible to study the diffusion of gases in water when the gas was placed above the liquid, and he was compelled to employ for his experiments a thin plate of the porous mineral hydrophane to hold up a column of water in an experimental tube, and so to provide the means of introducing the gas at the bottom of the water and of studying its upward diffusion through the water.

"Experiments for determining the amount of dissolved oxygen absorbed by sewage from fresh water and sea water, as well as the rate of re-aeration of a water with its dissolved oxygen content depleted by sewage, were made in the four tanks, each of which had dimensions 25 ft. long, 6 ft. wide, and 6 ft. deep.

"These experiments may be subdivided as follows:

"1. Dissolved oxygen absorbed in dilutions of sewage with fresh water:
  (*a*) Without surface agitation.
  (*b*) With slight surface agitation by two electric fans.

"2. Dissolved oxygen absorbed in dilution of sewage with sea water:
  (*a*) Without agitation.
  (*b*) With slight surface agitation by electric fans.
  (*c*) With the surface agitated, making a wave, without splashing, about 4 in. high.

"3. Rate of re-aeration produced by surface agitation in a mixture of sewage and sea water containing no dissolved oxygen."

In the writer's observation, simultaneous samples, taken at each foot of depth through ¼-in. galvanized pipes projecting through the sides of the tank, in almost every instance, gave the same amount of dissolved oxygen, the amount depending solely on the violence of the agitation at the surface.

When the surface was quiet the absorption of oxygen was small and seemed to be due to a change in temperature. The slight ripple of the surface obtained by the wind from two electric fans was sufficient to produce considerable absorption of atmospheric oxygen. A still greater absorption of oxygen was obtained by disturbing the surface with a 4-in. wave movement, produced (without splashing) by a vertical reciprocating action of a horizontally disposed furring strip located at the center and at right angles to the length of the tank.

It was noted that in fresh water, salt water, or in sewage, diluted with either fresh or salt water, the downward diffusion or gravitation of oxygen was practically instantaneous.

Neither the temperature of the water, nor the percentage of dilution of the sewage seemed to be factors in the rapidity with which this gravitation of the oxygen took place. The more violent the agitation of the surface, the greater the amount of dissolved oxygen was present. The amount of oxygen

capable of being absorbed depended on the temperature, salinity, and percentage of saturation of the liquid at the beginning of the agitation.

The tanks used were 6 ft. in depth and the observations were limited to a depth of 5½ ft. From extensive studies made at Duluth, Minn., Milwaukee, Wis., New York City, and other places, it would appear that as the effect of the wave action may extend to a depth of from 30 to 40 ft., that the depth to which this gravitation takes place would be practically the same.

In the experiments mentioned the change of temperature of the liquid was not rapid. In many cases the temperature of the liquid in the tanks was raised to 25° cent. (77° Fahr.) by heating with exhaust steam. The temperature of the atmosphere was 10° cent. (50° Fahr.). In such cases, the temperature of the liquid did not reach the temperature of the atmosphere during the 24 hours in which the observations were made. At the bottom the temperature was from ½° to 2° warmer than at the surface.

The rate at which the dissolved oxygen was reduced by the demand of the organic matter present in the liquid, depended on the temperature maintained in the tank. Where the temperature of the liquid was reduced from 20° cent. to 13° cent. within 24 hours, the rate at which the dissolved oxygen was reduced was practically the same as for liquid that was maintained at 20° cent. throughout the 24 hours. Where the temperature was higher than 20° cent., the rate at which the dissolved oxygen was reduced was much greater, but at no time was the reduction greater than the oxygen obtained from the surface when agitated by a ripple ½ in. in height.

In the case of the dilution of 1 part of sewage to 20 parts of fresh water with a ½-in. ripple, it was found that after the fourth hour the rate of absorption of atmospheric oxygen was about 0.18 parts per million per hour. With salt water the rate was 0.085 parts per million per hour.

Another observation was made with a mixture of sewage and salt water, which was devoid of oxygen. The surface was agitated with a 4-in. wave and, at the end of 4 hours, it was found that the dissolved oxygen, at all depths, had increased from 0 to 6.56 parts per million, or at the rate of 1.64 parts per million per hour. At the end of the fourth hour, the agitation was stopped, and the mixture allowed to remain quiet for 20 hours. At the end of this period, the dissolved oxygen had decreased to 4.50 parts per million, or at a rate of 0.1 parts per million per hour.

Diagrams and tables containing the detail of the studies on the absorption of oxygen were published in a "Report on Sewage Experimental Investigations at West New Brighton, Staten Island, N. Y.", by the writer and issued by the President of the Borough of Richmond, City of New York.

The author concludes that the rapid increase of dissolved oxygen in polluted tidal waters, when roughened by the wind, is caused by the increased area exposed to the air. The experiments of 1916 at West New Brighton seem to indicate that the rapid increase of dissolved oxygen in polluted tidal waters when roughened by the wind, is due to the oscillation of the waves breaking through the layers of the water to various depths.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

STREAM POLLUTION AND SEWAGE DISPOSAL

A SYMPOSIUM

Discussion*

By Messrs. John A. Griffin and Clarence E. Keefer.

John A. Griffin,† M. Am. Soc. C. E. (by letter).‡—The subject of stream pollution and sewage disposal is of particular interest to the writer at this time, in that the City of Los Angeles is confronted with the necessity of resorting to an emergency measure to cope with its overtaxed outfall sewer.

Los Angeles is one of the largest cities using a separate system of sewers, and the sewage is a relatively "strong" sewage. The diversion or disposal thereof into a relatively small creek which contains, in the dry season, a limited quantity of water, might tend to intensify the pollution of the creek. Practically, no water supply is derived from this creek and only a few wells are in proximity thereto. The level of the water in the creek is slightly lower than the ground-water in the surrounding areas, which would tend to drain waters from the land and wells to the creek rather than pollute the wells from the stream. However, pollution to any marked degree would become objectionable, due to the fact that the course of the creek is through a rapidly growing suburb.

The isolation of the creek at other points than Culver City, makes its use, as an emergency measure, safe and justifiable, although it is well recognized that a dilution of from 2½ to 5 cu. ft. of water per sec. per 1 000 people sewered is necessary to prove satisfactory under ordinary conditions, yet the writer believes that a much smaller dilution factor can be resorted to with safety in this instance. If experience should demonstrate otherwise, it will only be necessary to discharge in the head-waters of this creek, sufficient fresh water from the Los Angeles domestic supply to bring the dilution factor to a point within the limit of safety.

The rapid growth of the city has brought about a condition that is causing much trouble. The outfall sewer to the sea, constructed in 1907, has become

* Continued from January, 1922, *Proceedings*.

† City Engr., Los Angeles, Cal.

‡ Received by the Secretary, February 9th, 1922.

overtaxed to the extent that, in the dry-weather period, sewage has begun to flow out of the manholes into the streets and in the wet-weather period the discharge into the streets is enormous. This condition was anticipated nearly two years ago, and a bond issue was submitted to the people. This bond issue was defeated on June 7th, 1921.

With the overflow from the manholes into the public streets in a thickly populated section, came the apparent menace of epidemic and the necessity for immediate action. Although this overflow ultimately found its way into Ballona Creek over improved streets, it was necessary to provide a means to divert the surplus sewage to the creek without allowing it to flow along the streets. Permission to make this diversion has not been granted by the State Board of Health for the reasons previously mentioned, that is, the pollution of the small quantity of creek water, nor has sanction or permission been given for the use of the streets as natural channels to lead the sewage to the creek. In the absence of such authority, it was necessary, from a public health standpoint, to choose the lesser of two evils, and tap the outfall sewer near the head-waters of Ballona Creek to permit the surplus to flow directly thereinto without rising to the streets. This was done on January 4th, 1922, with the result that injunction suits have been filed by people down the creek.

The writer thinks that members of the Society may be interested in the peculiar position of the State Board of Health, that is, to grant a permit to use the creek for sewage disposal, even as an emergency measure, means the creating of a nuisance, with possible damage suits, whereas the ordering of the city not to utilize the creek, would result in using the public streets as sewage channels, with the consequent menace to the health of a considerable population.

The time required to put through any semi-permanent relief will be more than two years. The outlook is not good for quick relief, and although the writer has recommended that no extensions to the sewer system be made and that house connections to existing sewers be disconnected and cesspools be resorted to until a permanent relief is provided, it is doubtful whether this program can be effectively executed, due to legal and other difficulties.

Bacteriological tests of the water of Ballona Creek, at Culver City, indicate no considerable pollution even with raw sewage being discharged in the head-waters. When the sewage is fine screened and a small quantity of chlorine added, it is anticipated that no menace to health will exist. This meager emergency treatment will be carried on until permanent relief has been provided for the outfall. The time required for the sewage to flow from the proposed plant to Culver City is six hours and, under normal weather conditions, oxidation will be a material factor in its purification. Beyond Culver City practically no nuisance will exist with ultimate disposal in the tide-waters at Del Rey Beach.

Clarence E. Keefer,* Jun., Am. Soc. C. E. (by letter).†—The papers and discussions on this subject contain many points of interest. The paper by

* Asst. Designing Engr., Sewer Div., Highways Dept., Baltimore, Md.

† Received by the Secretary, February 23d, 1922.

W. H. Dittoe, M. Am. Soc. C. E., on the "Prevention of Misuse of Sewers"* should appeal to those in charge of the maintenance of sewerage systems. Baltimore, Md., is a striking example of a city with a separate system of sewers, where efforts have been made successfully by the city authorities to have these sewers put to their proper use. This condition is accomplished by co-operation between the Sewer Division and the Health Department of the city, and the Master Plumbers' Association.

The municipal laws require that, before the plumbing system of a house is connected to the city sewers, a permit must be obtained from the Health Department. The connection to the sewer is made by a master plumber and inspected by an authorized city employee. If it is found that there are any rain leaders emptying into the sanitary sewers, they are immediately ordered to be disconnected. In those parts of the city that are unsewered, the sewage is usually collected in cesspools. When sewers are built in sections of the city of this character, it is usually necessary to re-arrange the plumbing in the houses; and before this work is finally completed, inspections are made to see that it is done properly. Occasionally, it is brought to the attention of the Sewer Division that either cellar drains or rain leaders are connected to the sanitary sewers. Under such conditions, an investigation is made, and if the work was done by a master plumber, he is warned not to do so again, and, in case he did, his license would be revoked.

In addition to laws governing the control of rain water entering sanitary sewers, there are other laws which make it illegal to dispose of gasoline, kerosene, germicides, or solid wastes into these sewers. As Mr. Dittoe has stated, more is required than the passing of laws governing the misuse of sewers. It is essential that these laws are enforced, and until this is done the best results will not usually be obtained.

One thing which should be provided for by cities is a law requiring property owners to connect their plumbing to the sewers. Quite often, when a sewerage system is built, there will be a few property owners who for one reason or another either will defer making their connections to the sewers or not to do it at all. In Baltimore, the property owners are notified when the sewers adjacent to their houses are completed, and they are given thirty days, with a reasonable extension of time, to connect their plumbing to these sewers. Usually, there is no trouble in getting them to do this. In case they should make any prolonged delay, however, the work is done by the city authorities, and the property owner is billed or assessed for the improvement made.

In the paper by George T. Hammond, M. Am. Soc. C. E., on "Tanks and Fine Screens for Treating Sewage",† he speaks of the use of separate sludge digestion tanks in the treatment of sewage. As is generally known, these tanks have been in use at Baltimore for about 10 or 12 years, and a great deal of information has been collected to date. However, much additional work will have to be done before the design of sludge digestion tanks is perfected. The first tanks built at Baltimore were rectangular in shape, each being 140 by 103 ft. in plan and from 13 ft. 6 in. to 15 ft. 6 in. deep. The

* *Proceedings,* Am. Soc. C. E., December, 1921, p. 642.

† *Ibid,* p. 618.

sludge enters these tanks through a 12-in. cast-iron pipe at the top of the tanks. Three inlets are provided for each tank. On the opposite side from the inlet pipe, there are three outlets at the bottom of the tank. When these tanks were designed, it was thought that, as the sludge digested, it would settle to the bottom, while the undigested sludge would remain at the top. Until August, 1920, the reverse condition prevailed. Practically all the digested sludge collected at the top, in the form of a heavy scum which was fairly dry. In fact, at times it was sufficiently hard to bear the weight of a person in walking. On top of this scum, grass, weeds, and other vegetation grew to a height of a foot or more. The sludge as it entered the tank sank through this scum, and flowed under it directly to the outlets. The horizontal distance of flow was about 100 to 125 ft. No figures are available showing the time it took for the sludge to arrive at the outlet, but, in many cases, it was only partly digested. The moisture content of the scum was approximately 70%, whereas that of the sludge beneath was approximately 80 per cent. In order to move the sludge from these tanks through the 1 100 to 1 900 ft. of 12-in. cast-iron pipe line to the sludge drying beds, it was necessary to break up the scum with a stream of water.

In addition to these rectangular tanks, there are sixteen cylindrical tanks, each 38 ft. in diameter and 24 ft. 6 in. deep. Each tank has a capacity of 20 610 cu. ft., with inlet and outlet pipes, 8 in. in diameter. The inlet pipes are at the tops of the tanks, and the outlets are at the bottom. As in the rectangular tanks, the digested sludge forms a scum on the top, and the undigested sludge remains at the bottom. Within the last few months, an additional sludge digestion tank has been built, in which various improvements over the old tanks have been embodied.

As the problem stands to date, it is possible to formulate certain principles pertaining to the design of sludge digestion tanks at the Baltimore plant. The depth of the tanks does not govern the degree and speed of sludge digestion. At present, designs are under way for three additional tanks which will have an approximate capacity of 650 000 cu. ft. In the future, it is likely that the tanks at Baltimore will have a depth varying from 15 to 20 ft. It is natural that the topography of the location of a sludge tank should be one feature governing the depth of these tanks. Where there is sufficient land available, and conditions warrant it, there is no reason why long shallow tanks, such as those at Birmingham, England, cannot be used.

One fact that has impressed itself on those connected with the operation of the sludge tanks at Baltimore is that the inlets should be as far away as possible from the outlets, in order to prevent the short circuiting of the sludge, which condition has frequently occurred. One obvious and simple method of doing this is to construct in the tank a series of vertical baffles around which the sludge can flow to the outlet. The inlets should be designed so that the incoming sludge can enter below the surface of the sludge in the tanks. This is necessary, because if the incoming undigested sludge is allowed to spill through the air, disagreeable odors will be disseminated. In the last sludge tank built, the outlets were placed at various elevations so

that there would be a possibility of drawing off the digested sludge at different elevations.

The capacities of sludge tanks should depend largely on the quantity of material to be handled. The cylindrical tanks, of which there are sixteen in Baltimore, are thought to be too small for the large plant there. The maximum size of sludge tanks will depend on the quantity of sludge to be handled. At Baltimore, it is not likely that tanks will be built having a capacity of more than 250 000 cu. ft. One necessary appurtenance to a sludge tank is a flushing water line so that water can be added, in case scum forms, and the scum broken.

About four or five months ago, an unexpected condition occurred in the sludge digestion tanks at Baltimore. In one of the rectangular tanks, gas action which was prevalent over the entire surface of the tank took place, and, in a short time, all the scum had sunk. Sludge from this tank was immediately put into the other two digestion tanks, and, before cold weather began, the scum had settled to the bottom, and gassing was occurring in all three tanks. When this gassing started, there seemed to be an intimate mixture of the digested and the undigested sludge, with a consequent increase in digestion. One other condition noted was that this material flowed readily through the 12-in. cast-iron, pipe line to the drying beds, frequently without having to be pumped. Furthermore, it was no longer necessary to add water in order to break up the scum so that it would flow to the pump. Whether this gassing action will start again in the spring is problematical, but every effort will be made to study its causes and have it occur if possible. Much remains to be done on the investigation of sludge digestion, in fact, various experiments have been conducted for the past 18 months on sludge digestion at Baltimore.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

WATER TRANSPORTATION
A SYMPOSIUM
Discussion*

By Messrs. Gardner S. Williams, J. E. Willoughby, John C. Trautwine, Jr., Augustus Smith, C. C. Vermeule, and B. F. Groat.

Gardner S. Williams,† M. Am. Soc. C. E.—Considerable has been said, as to the relations between the carrying capacity of the American sea-going merchant marine and the exports and imports. There must be some legitimate ratio between the tonnage of exports and imports which go from and come to the United States and the proportion which its marine is entitled to carry, assuming that each nation in the world has its share. The world is gradually coming to the point when no one nation will be permitted to take all the profits of any particular line of business. It is obvious that the United States cannot expect to carry all its exports and its imports, because if it did, there would be some nations that would have nothing to carry. If the United States has the right to carry its exports, then every nation which would export to this country has a right to carry its exports. A merchant marine cannot be operated which has cargoes only one way, so a portion of the imports must be carried as well as the exports. The statisticians should determine just what proportion of the imports and exports of the United States it is rationally, legitimately, and fairly entitled to carry, in justice to its neighbors in this world, and how far that proportion is from the amount carried. If every nation were a carrier, the answer would be one-half of each, but some nations are not carriers, hence there is a problem to be solved.

On the Great Lakes, it has been found that a certain speed of vessel was the most economical for the service required there; or, rather, that, for particular services, vessels of certain speeds are the most economical. That same condition must exist on the ocean. Probably that has been investigated, but the speaker does not know where to find the figures. In regard to the matter of subsidy, it seems that a subsidy should only be used where the conditions

* Continued from February, 1922, *Proceedings*.

† Cons. Engr., Ann Arbor, Mich.

of the service require that the constructors or the maintainers of that service should depart from that which is most economically profitable; in other words, if it is necessary that ships of a higher speed than is economically profitable are introduced into the service, then the Government should countribute to that; but if it is not necessary that the ships should be built for any more than the most economical operation, then it seems that it is questionable whether a subsidy should be granted. Many believe that if the Government will remove some of its restrictions, private industry will overcome the remainder of the difficulties. Conditions exist in this country, that do not appear in all the countries abroad. It is perhaps unfortunate that the American wants to live on such a high plane or, perhaps, it is a good thing that he does; but there are times when it militates against the prosperity of the country as a whole, if he insists on having things which are not necessary. These are, however, problems that probably Government cannot handle; but if the United States cannot maintain a merchant marine without bringing a greater burden on itself than the benefit which the marine will bring, true statesmanship would decide that normal industry must take its course.

J. E. Willoughby,* M. Am. Soc. C. E.—The speaker agrees with the views expressed that the Federal Government should render some aid to the trans-oceanic shipping, but such aid should not be rendered to coastwise vessels, because it will be subsidizing those vessels to the injury of the coast-line railroads.

The speaker has the impression that there are, on the statute books, various laws with respect to wages and working conditions that make for waste in marine service, and it is his opinion that the attention of ship owners might properly be directed to the repeal of those laws, as well as to subsidies, which are necessary in order to make the merchant marine a success. The railroad with which the speaker is connected has long worked in co-operation with certain coast-line vessels as a distributor to interior points of traffic from the North Atlantic ports to those of the South Atlantic. In the past, a success has been made of that distribution and it will be continued. Recently, there has been established, in compliance with the orders of the Interstate Commerce Commission, certain rates that affect traffic between the ports mentioned, and these rates will cause the abandonment by the railroads of part of the traffic between those ports (other than such as will be distributed to interior points), and establish the carrying of that traffic by coastwise vessels as the cheapest routing. Transportation under the new rates between the port cities of the South and North Atlantic is so much cheaper by water than by rail, that the railroads are abandoning the carriage of certain commerce.

John C. Trautwine, Jr.,† M. Am. Soc. C. E.—The papers on "Water Transportation", indicate that a conflict of interests exists, not only between water and rail transportation, but between these two combined, or, briefly, "capital" and "labor", to say nothing of the public interest as an apparently negligible third.

* Chf. Engr., Atlantic Coast Line Railroad, Wilmington, N. C.

† Philadelphia, Pa.

For instance, Dr. Johnson* states that American ocean shippers are at a disadvantage, as compared, with those of Europe, by reason of the higher wages prevailing here; and although it is the fashion to deprecate Governmental interference with "business", "Government" is looked to, to come to the aid of the impoverished American shipper, as against the American laborer.

So long as economy remains based on the obsolescent profit system, the business structure is necessarily a pyramid standing on its apex; and it is the delicate task of the Government to prevent it from toppling over, in one direction or the other, and crushing this or that "interest" in its fall.

Augustus Smith,† M. Am. Soc. C. E.—The remarks by Mr. Williams and Mr. Trautwine have made the speaker realize that his business, which is fabricating structural steel, is related in some way with this matter of water transportation.

The speaker has in his library a book, entitled "Tales of an Old Sea Port." The stories are of famous American voyages and ships that sailed from Bristol, R. I., and carried the American flag to all the "seven seas." An outstanding feature is that, in those days, the crews from captain to cabin boy, participated in the profits of the voyage. Much the same economic arrangement exists to-day in the fishing industry at Gloucester and elsewhere.

The speaker offers the thought that it might be possible to stimulate American shipping anew if this old co-operative basis was again adopted, having legislation amended, if necessary, so that when owners and crews so choose, they might share in the profits of a voyage.

Thus, a method of computation might be to estimate a vessel as worth so many thousands of dollars, a seaman worth, say, \$15 000, a captain, say, \$30 000, and so on, placing a capital value on every one of the ship's company. When the ship returned to its home port, the profits would be divided according to the "invested capital". On such a basis, if a vessel earned fuel, food for the crew on the voyage, and the necessary repairs and maintenance, there would be no "loss", and men in the business of fabricating structural steel on shore would not have to be called on to make good any deficit. Such voyages would appeal to the spirit of adventure in all young men and would attract good American blood and might well yield handsome profits.

C. C. Vermeule,‡ M. Am. Soc. C. E.—At the foundation of all sound engineering lies economics, and by his training and experience, the engineer is fitted to lead the way to a rational economic policy on which regulation of transportation and expenditures of public money for any purpose should be based. Speaking from the standpoint of the great industries of the country, the time has come when strict attention must be paid to conserving public funds and restoring to private enterprise a reasonable freedom of action. A serious difficulty arises when Government undertakings compete with private enterprise in the field of transportation, or other business, for, at once, the normal economic balance is upset. This is mainly because public money is not used, and there is not sufficient incentive to its use, with the same strict

* *Proceedings*, Am. Soc. C. E., February, 1922, p. 274.

† Pres., Bergen Point Iron Works, Bayonne, N. J.

‡ Cons. Engr., New York City.

insistence on proper financial returns that obtains when private capital is utilized. The latter must earn dividends or be driven to bankruptcy, whereas the Government enterprise can always, but improvidently, dip more deeply into capital account to make up a deficit in earnings.

No invidious application to the operations of the Shipping Board is intended. It is too well known that the Board inherited an economically monstrous condition at the end of the World War. It should be considered, however, what would have been the course had a business man found himself confronted with the same state of affairs in a private enterprise. As a good business man, he would unquestionably have made up his inevitable losses as promptly as possible and started afresh on a sound, economic basis. Is there any sufficient reason why the same course should not have been followed by the Government? If industries and agriculture are to prosper, they must not be forced to maintain, through a false National pride, a merchant fleet which cannot furnish them transportation at rates as low as their competitors can obtain. Nor can this be a fictitious rate, with resulting deficits to go into the tax bill. Nothing but really economical transportation will permanently help the industries. Competition has now become international, and if business is to thrive, it must be able to command the markets of the world.

A short time ago it became necessary, in connection with industrial operations, to make some forecast of the future level of wages and prices, a question which so often presents itself to the engineer in his work. It was determined that one of the most important factors which will influence that level, is to be public expenditure. The effect of reckless use of public money by National, State and municipal governments, is that the average worker in the United States must now produce $200 a year for Government expenditure. There are 42 000 000 workers engaged in gainful occupations in the United States, and it is well known to students of economics that their average earnings in 1915, or just before this country went into the war, only amounted to $680 yearly. An investigation covering sixty years reveals the fact that at no time has it been found possible to collect directly or indirectly from the worker more than one-seventh of his earnings for Government use. Consequently, on the 1920 basis of public expenditure, he must earn not less than $1 400 annually, or more than twice as much as before the war. Many workers are being paid this much, but are they earning it? If not it is coming out of the stored up National wealth and the country is growing poorer. Some economy has recently been effected by the National Government, but State and municipal expenditures still tend to increase, and the blame for this rests more often with the people, who advocate every conceivable project requiring public money, than with the office holder. Due mainly to the scale of public expenditure, it seems impossible that wages will drop to a lower level than 45% over pre-war figures, which means that prices of all commodities will not fall permanently below the same level, as wages will always be a controlling factor in costs.

Unfortunately, a large number of people believe that taxes can be collected from the rich alone. It is still more remarkable, notwithstanding it has become an established principle that public utility rates are determined by cost, that the people believe that these enterprises can be taxed without the

bill coming back to them in rates. It is most important that engineers, who know better, shall do all in their power to correct these errors, for as long as they prevail, the nation will never come to a sound, economic basis. When every one realizes that every dollar of public money must be contributed from private funds, the public will insist that such money shall be used with the same care and shall produce the same financial and economic result that is insisted on when private capital is utilized in enterprise. It may be easily shown that if the rich or the provident alone were called on to pay all the taxes, their liquid assets would be exhausted at the end of two years, and when that point was reached, the remainder of their assets, with most of the National wealth, would become worthless for lack of purchasers. Again, taxes cannot come out of the industrial or transportation enterprises, for there is hardly one of them that could survive more than three years if it could not recover its taxes through increasing the prices of its product. Many of the great transportation companies are paying in taxes from 9 to 10 cents out of every dollar which they collect in rates, and it should be self-evident that both these and the public utility companies must increase their charges to the public to provide the money to pay these taxes.

It is useless for the Government to build fine highways, or other public works, or to conduct a shipping industry, or other transportation enterprises, if it thereby takes from the worker so much of his earnings that his purchasing power is greatly reduced, or if it destroys manufacturing and agricultural interests through excessive taxation. Consider for a moment the effect on the smaller industries, for it will illustrate the harmful results. Assume a concern beginning with $100 000 capital, and manufacturing, perhaps under patents, a useful product which enables, in a given year, a profit of 100% to be realized, and some of them are fortunate enough to do so. During the next year, their growing business will certainly require twice as much capital, but their profits are largely locked up in additions to plant and book accounts. Nevertheless, as conditions have been recently, the Federal and local governments call on them for perhaps $50 000 in taxes, which must be paid out of liquid assets. Bankers do not care to loan them money to pay taxes, and, consequently, these young concerns are deprived of capital which they need to provide for their growing business, and they cannot employ labor, expand, and produce. It is by such healthy young enterprises that the best business of the country has been built up, and to prohibit their activities, causes a serious loss to the wealth of the nation at large. These are the enterprises which will furnish freight to the railroads and ships of the future, and which must be able to obtain their ocean rates on a basis that will enable them to compete with the other industrial nations of the world.

In this connection, the effect of unwise Government regulation of railroads upon the industrial situation may also be considered. No better illustration is known than the story of freight on carload lots of steam coal in New England, for the cost of coal is a most important factor in the future of industries. From 1895 to 1916, the average level of wages and prices was increasing at the rate of 10% compounded every 5 years, but through ill-advised Government regulation, freight rates had not been allowed to advance and were slightly

lower in 1916 than they were in 1900. New England industries had accommodated themselves to these fictitious low rates, and much money had been invested thereon. It was found, when the Government faced war, how short-sighted this crippling of the railroads had been, and the rate from the Cumberland District to points near Boston was suddenly jumped from $2.95 to $5.28 per ton. This sudden advance has been most disturbing to industry, and, particularly, since the level of prices has fallen and business has come again to a strictly competitive basis. Because of the great economies effected in railroad transportation, it would not have been necessary to increase the rates as rapidly as the average of wages and prices. Had this been done, it would have brought the rate on coal to $4.20 in 1916 instead of $2.95. It is perfectly apparent, however, that the rate in 1915 should have been 25% higher than it was, or, say, $3.75 per ton. Had this been permitted, industry would have accommodated itself thereto, because the increase would have been gradual and proportional all over the United States, and could have been easily absorbed. It would seem best to come back to the old principle of charging what the traffic will bear, for to destroy all industries remote from the coal fields is unthinkable. It is necessary and just, however, that the railroads, in their present condition, shall be allowed a somewhat higher rate than $3.75, in order that they may make up for past deficiencies, due to unwise Governmental interference.

Past experience shows, therefore, that it is dangerous to the business of the nation when the Government enters competitively therein; there is also a limit to the taxes which can be imposed on industry to furnish money for unwise undertakings. Although the principle of public regulation of utilities has been accepted as correct, no way has yet been found to apply it wisely, and as now practiced it is also a menace to the whole business of the country. Last, but not least, the merits of all proposals to expend large amounts of public money should be most carefully examined and from this examination should be excluded all mere pride of achievement of ends that will not produce a direct and certain profit to the average worker whose earnings the Government is investing. Whether such expenditures of public funds would be entered into with private capital, by reasonably conservative business men must be considered seriously. If not, there should be sound reasons to justify them, before they are undertaken. Everybody knows of many things they would like, but for which they cannot pay; the nation is now in the same condition.

The trained minds of the Engineering Profession are needed to concentrate patriotically and unselfishly on these great questions, and it is their duty as good citizens to contribute all they can to the establishment of a wise, conservative, economic policy, for as stated previously, as the basis of true engineering, of real accomplishment, and of prosperity in the profession, we must have sound economics, no matter whether the funds to be invested are public or private.

B. F. Groat,* M. Am. Soc. C. E.—The speaker will mention what he believes is nearest the hearts of those interested in water transportation,

* Civ. and Hydr. Engr., Pittsburgh, Pa.

namely, the question of a subsidy. As a general rule, the speaker is constitutionally opposed to subsidies, but it seems that an American merchant marine is an exception to this rule. The United States has to compete with the remainder of the world, and if the remainder of the world can bring in commodities cheaper than this country, when measured in dollars and cents, which is not always a safe measure, then he is in favor of the subsidy.

There are many ways of granting a subsidy. An example of the price of water power will illustrate. The water-power policy in this country seems to demand that such power be sold at a less price than steam power of the same character. In the case of steam power, a certain supply may be had from a given plant, which is not the case with water power. River flow is variable, and one cannot afford, in all cases, to spend money enough to regulate the river completely. Therefore, there are two kinds of water power, continuous and variable. The continuous water power is like steam power, it is always available. The variable kind may be divided into two parts, or kinds, one of which will be called dependable seasonal power and the other mere surplus power which comes in varying quantities and for variable periods, sometimes lasting for months, or even years, only to vanish as unexpectedly as it appeared.

In the case of continuous power, there should not be any difference between the price of water power and that of steam power, assuming an open market, just as there should be no difference in the price of commodities from one section of the country as compared with the price of similar commodities from another section, because one farmer can produce his crops more cheaply than another. There is a market for such things. In the case of water power, however, the policy seems to be to compel the sale of water power for less than the market price of steam power.

What is the result? For example, take a large manufacturing establishment which can obtain a supply of water power at a price lower than the market price of steam power. That establishment immediately has the advantage a subsidy would give. Such subsidies are granted in such a manner that they are frequently unrecognized as such by the grantor, and thus some great industries have been subsidized. If one examines the development of water power at Niagara Falls, he will appreciate this fact. The manufacturers get the power at comparatively low rates. The manufacturer has, in effect, a subsidy, and it is granted substantially in the manner described.

With a merchant marine, it is not only a question of economic advantage to maintain it, but, to a certain extent, it is also one of patriotic pride. One may say that patriotic pride is not an economic force, but the speaker is convinced that it is. Who will belittle the economic value of having the American flag flying in every harbor of the world?

Only one other point will be discussed, and this was touched on by Mr. Williams and others, that is, the best speed of a ship. The speaker does not believe there is any such thing, that is, when one takes into account all the variable factors at one period and under one state of economic and mechanical conditions, there will be one speed, and under changed conditions there will be a different speed. Here, again, the same thing is found in water power.

There is said to be a best speed for a water-wheel, and yet, when one tries to apply that principle practically, he will find it a difficult problem. The best speed varies from day to day, according to mechanical and hydraulic as well as other conditions; and the speaker thinks the same thing must be true of ship speeds.

It seems not unlikely that ships should have different types of propellers to meet varying conditions, especially the economic conditions. The speaker would not dare to say that economic conditions will not arise requiring that sort of thing, although he is aware of the nature of the difficulties to be overcome in providing suitable marine power plants for such purposes.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications.

SOME NOTES ON THE LOCATION AND CONSTRUCTION OF LOCKS AND MOVABLE DAMS ON THE OHIO RIVER, WITH PARTICULAR REFERENCE TO OHIO RIVER DAM NO. 18

Discussion*

By Thomas P. Roberts, Esq.

Thomas P. Roberts,† Esq. (by letter).‡—Referring to the late W. Milnor Roberts, Past-President, Am. Soc. C. E., the author states that Mr. Roberts recommended locks with movable tops on Ohio River dams. The fact is, he never recommended "movable tops" on dams, as such term is understood by river engineers. In 1839, in a report to the Monongahela Navigation Company, he advocated the extension of locks with fixed dams for the Ohio River, such as he was constructing on the Monongahela. Later, in 1857, in a paper published by the Franklin Institute, Mr. Roberts repeated more fully the same recommendation. In 1866, he was made one of the two U. S. Civil Engineers, authorized by Act of Congress, and assigned to the Ohio River to complete the survey of that stream from Pittsburgh, Pa., to Cairo, Ill., and to undertake minor improvements for the immediate betterment of navigation. The chief object of his employment by the Government was to obtain his views on the various schemes, or projects, which had been referred to the Chief of Engineers for the radical improvement of the Ohio.

In his final report, dated April 21st, 1870, Mr. Roberts, referring to the dams he was recommending, sanctioned the idea of placing in them "chutes" 300 ft. wide, for the benefit of descending coal fleets, and thus make navigation practicable for them, even during moderate rises of the river. The chutes were not described in detail in his report, but, to the writer, he stated that chute shutters might be made, say, 3 ft. deep in dams of 6 ft. lift, such as were contemplated by him. The shutters were to be raised by a shaft operated

* This discussion (of the paper William M. Hall, M. Am. Soc. C. E., published in January, 1922, *Proceedings*, but not presented at any meeting of the Society), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

† U. S. Engr. Office, Pittsburgh, Pa.

‡ Received by the Secretary, February 20th, 1922.

from the lock wall, the shaft turning geared wheels at proper intervals beneath the shutters. The time required to raise them against the water pressure was a matter of indifference, the longer the time, the less the power required. He clung to this idea even after meeting the late Col. William E. Merrill, Corps of Engineers, U. S. A., M. Am. Soc. C. E., his successor in charge of the Ohio River, who had but recently returned from France, where he had seen and was greatly pleased with the Chanoine wickets on the Marne and Upper Seine Rivers. Concerning the project of Mr. Alonzo Livermore who had constructed the locks and dams on the Green River, in Kentucky, Mr. Roberts made no objection to placing a contrivance in the form of a down-river extension of chutes in dams, arranged so that current velocities could be reduced sufficiently to enable ascending steamers to pass through the chutes. Mr. Livermore was to demonstrate the feasibility of his project, which, although theoretically practicable for clear water, might not have been advisable for rivers in which snags and drift complicated the problem during floods.

In an historical review of other projects for river improvement, submitted to Mr. Roberts for his opinion, it may be permissible to refer briefly to some of them. The most important of these was suggested, years prior to the Civil War, by Col. Charles Ellet, a distinguished writer on river hydraulics, as well as on railroads and bridges.

Based on ten years' records of rainfall and river discharge at Wheeling, W. Va., made under his personal supervision, Col. Ellet demonstrated that a 6-ft. minimum to 9-ft. maximum stage could be permanently maintained on the Upper Ohio, provided the excess of flood water on tributaries could be stored in reservoirs. This project was so ably set forth by Col. Ellet and Mr. Elwood Morris, as to attract much public attention and was even favorably considered by Congress which was about to appropriate a large sum for starting surveys for reservoirs, when Mr. Roberts, almost alone in his opposition, interposed with his pamphlet entitled, "Practical Views on Ohio River Improvement". He showed that, in 1847, to have had full control of storm waters, the reservoirs above Wheeling should have had a capacity of over one trillion cubic feet. His strongest point was that the records indicated the probability that some of the more important reservoirs would have been full when certain floods occurred. Other river engineers, including Col. C. McD. Townsend, U. S. A. (*Retired*), M. Am. Soc. C. E., formerly President of the Mississippi River Commission, have since demonstrated that, as great river floods frequently originate from comparatively limited areas, for instance, such as have created very high floods at Cairo, such floods might be aggravated by waste waters from reservoirs at the head of the Ohio, etc. It has been proved that to reduce materially the height of great floods at Pittsburgh, restraining reservoirs should be as near as possible to the city, for the flood-producing storms reaching Western Pennsylvania are only rarely more than 90 miles in width of excessive precipitation. However, on rare occasions, Nature doubles, or even trebles, what is termed her excessive precipitation, as appeared in 1913 over Northern Indiana and Ohio, just covering about one-eighth of the Allegheny River water-shed. That one-eighth, however, with a precipitation of from 7 to 9 in., produced a flood which at Pittsburgh, 100 miles below,

was greater in discharge than any preceding flood developed from more than triple the same storm area. Had the 1913 storm moved eastward only 80 miles farther, careful study indicates that, at Pittsburgh, the flood would have been at least 15 ft. higher than the record flood of 1907. It is useless to attempt to estimate the damages which would have resulted from such a flood to the towns, bridges, etc., above Pittsburgh. The 200 acres of low land embraced in the business section of that city, with currents of from 8 to 10 miles per hour, of from 12 to 14 ft. in depth, through its streets, can be imagined if not described. What would have been left for salvage of the city would have been chiefly steel beams, protruding from a great area of gravel, building materials, etc. To talk of restraining reservoirs for such floods, at least for the area above Pittsburgh, is waste of time. From the evidence of the topography of the Allegheny Valley, glacial drift remains, etc., no such flood has occurred at Pittsburgh since the last flood waves of the glacial epoch passed along the Upper Ohio Valley not less than 10 000 years ago.

Wrong impressions of the transportation capacity of the Ohio River, when finally improved, should not be perpetuated in the publications of the Society. It is of the first importance that Congress should not vote away public funds on projects that will not adequately benefit the public interests. More and more it is being demonstrated that without the utilization of the inland waterways to cheapen transportation to the seaboard, all hope of a world-wide extension of commerce must be abandoned. The railways now staggering under the loads imposed on them, would be greatly relieved if some, such as coal, and other items of low intrinsic value, could be taken from them.

It is unfortunate that the river engineers of the United States competent to portray the advantages of waterways are, in a way, debarred from promulgating their views, but must usually confine themselves to the engineering duties assigned them. On the subject of the real potential capacity of the Ohio when improved throughout its entire length, Mr. Hall writes* as follows:

"The capacity of the river for package and barge freight, when the improvement is completed, would easily be 25 000 000 tons annually and possibly double or treble that quantity. However, during the months the dams are up, the lockage capacity would be much below that rate."

From such a statement the inference is that locks 600 ft. long by 110 ft. wide (the same width as provided for the Panama Canal), and 9 feet deep on gate-sills, would be "much below" a capacity of 25 000 000 tons annually.

In the Pittsburgh Engineer District there are included ten locks 600 ft. by 110 ft. on the Ohio, three locks and dams on the Allegheny River, and fifteen locks and dams on the Monongahela River. Six of the dams on the Monongahela, next in order above Pittsburgh, are provided with twin parallel locks averaging a lift of about 9 ft., with available chamber dimensions of 360 ft. by 56 ft., with limiting depth, at one lock, of 9.2 ft. on gate-sills, up to, and including locks, at Dam No. 6. Yet, during 1920, with practically all the traffic being compelled to pass through the locks, there was accommodated 24 000 000 tons.

* *Proceedings*, Am. Soc. C. E., January, 1922, p. 9.

The lock most used was at Dam No. 3, where for three months during 1920, the traffic was confined to one lock chamber. During this period of three months, there were passed through the single lock in one day 93 000 tons, with not quite all the time available for locking utilized. The tonnage was nearly all down stream, while empty fleets (which might as well have been loaded) passed upward. Upward bound fleets meeting descending fleets have both been passed through Lock No. 3 in 35 min., although 40 min. are usually allowed (single steamers, of course, in both directions in considerable less time). Had this traffic through a single lock at Dam No. 3 been maintained for a year of 280 days, it would have amounted to nearly 26 000 000 tons.

Only stern-wheel boats equipped with balanced rudders are used on the Monongahela. When backing their wheels, these boats develop an enormous steering power, and are capable of doing such a business safely in the narrow confines of lock approaches. Collisions of vessels or serious damages to lock-gates are rare occurrences on the Monongahela. "Tunnel boats", or independent double-screw boats, will probably never be built for the rivers about Pittsburgh, as they are all deficient in steering power. Pittsburgh is the seat of inland waterway transportation, more than equalling the present tonnage of the entire Mississippi and its tributaries below the city. Here, also, were made, at much cost, experiments with bear-traps, Chanoine wickets, roller lock-gates, etc., leading up to further improvements elsewhere on the river. There is no better school than "the school of experience".

The Monongahela locks will now be compared with those built, or in process of construction, on the Ohio. Fleets of 9 000 tons have been frequently passed down the Ohio through Locks Nos. 1, 2, and 3, which locks have the same dimensions as all locks on the river below to Louisville, Ky., 600 miles below Pittsburgh. These fleets were passed through these locks, generally in 20 min., and ascending fleets meeting descending fleets, including the time required in filling the lock chambers, were passed in 45 min. Considering adverse winds, and contingencies of freshet currents approaching locks, it is considered safe to say that fully 10 000 tons per 50 min. could be passed down the river, and a theoretical tonnage of nearly equal amount might be passed up. Therefore, 50 min. would permit of twenty-eight down, and twenty-eight up, lockages per diem. Ignoring up-stream tonnage and restricting down lockages to 8 000 tons would make a possible down tonnage of 224 000 tons daily, as compared with the 93 000 tons daily for a single lock on the Monongahela, previously referred to.

The writer has been in charge for more than 20 years of Monogahela locks and dams and is fully aware of the liability of locks being closed for repairs, necessity for which at times may put a lock out of commission for extended periods. The Ohio locks, however, have an important advantage over those on the Monongahela, where there is no open-river navigation, in the fact that, on the Ohio, repair work is often practicable during the periods of open-river navigation, or when the locks would not be used by passing vessels. Doubtless, however, Ohio River dams, in due time, as necessity arises, will be provided with second locks, such as are already constructed at the Emsworth Dam on the Ohio, 9 miles below Pittsburgh.

As open-river conditions will be maintained longer on the Ohio River below Wheeling, 90 miles below Pittsburgh, than above that point, there will be a greatly lessened dependence on locks below in the river to Cairo. With open-river conditions, the capacity of the Ohio for traffic, of course, would be exceedingly great, but one must not be unmindful of the fact that, for a regular annual traffic on the Ohio, the worst low-water conditions should be assumed, for the traffic is not dependent on weather conditions, but comes from human needs—"the law of supply and demand." It can be depended on that the capacity of the river when the growth of traffic demands it, can be made considerably over 100 000 000 tons per annum passing any given point, or more than four times the present annual traffic of the Monongahela River with its small locks and no open-river navigation.

At the risk of unduly prolonging this discussion, the writer urges attention to an important topic raised by Mr. Hall in the last paragraph of page 8.* It concerns, as he says, the "fallacy of free rivers" improved and maintained by the Government and left for "Tom, Dick, and Harry" to rival each other in picking up package freight and cutting each other's throats with lower and lower rates, until finally no profit is possible. At present, the Ohio is, to a considerable extent, only a playground for the owners of small locally owned boats engaged in short-distance transportation. Under such circumstances, no responsible companies will undertake to construct on a large scale, first-class terminals and operate steamer and barge lines on schedule time, and never will, until something is done under the auspices of the Government. The writer in saying this does not wish to discredit several small companies recently organized to place steamers on the river above Cincinnati to Pittsburgh. They are doing well and their business is increasing.

In time there must come on the Ohio, steel barge lines towed in fleets for long-distance transportation, that is, freight towed in fleets separate from the miscellaneous light traffic possible for fast passenger boats, before traffic worthy of attention will be developed. The barges will have to be loaded at the mills and mines in 500 to 1 000-ton lots, otherwise, the old low ton-mile rate will never be revived. Rivers in this respect are in no way different from railways. However, with rivers, no maintenance of "roadbed" is necessary.

The writer, several years ago, stated in a published article that the freedom of navigation on the Western rivers had led to almost the entire extinction of traffic on them. Nevertheless, it is best that the rivers be left free, if for no other than physiological reasons. To charter companies, would lead to the development of animosities fraught with mischief.

To revive interest in the rivers, the writer proposed a plan somewhat as follows: First, the appointment of a commission by the Government directed to visit every important commercial or manufacturing community along the rivers (say, for a trial section the Ohio between Pittsburgh and Louisville, 600 miles), the navigable tributary streams to be included, to obtain information as to their commercial or manufacturing resources, tonnage traffic, etc. Second, that the commission be authorized to meet boards of trade or prominent business men and inform them that for the cost of modern terminals

* *Proceedings*, Am. Soc. C. E., January, 1922.

and railway connections the Government would subscribe 51%, provided the citizens of the locality subscribe 49% of said cost, the Government guaranteeing 3½% on all private investments (approved by the commission, and, later, of course, indorsed by the National authorities). Third, that boat lines, steamers, barges, repair yards, etc., be organized in the large cities on the same basis, no profit in the operation of boat lines or terminals to be in excess of 3½% on the total investment of capital including maintenance, renewal of plants, etc.; any further profit desired by private subscribers to be found only in the extension of their business by trading with distant markets secured to them by the boat lines.

The writer's conviction, was and is that this is the best and surest method of interesting vast numbers of people in the benefits of inland navigation. Any small companies desiring to compete with the semi-national boat lines should be allowed to do so, except that they should pay proper charges, where they utilize the National terminals. All the Government desires is to develop the usefulness of the rivers. If private boat companies can be organized to do business, on a reasonably large scale along the rivers, at rates lower than the official rates, then the "official" boats can be withdrawn from the trade and utilized elsewhere. Private subscribers to terminal landings, where such would be abandoned for lack of income, should be refunded.

With this proposition nothing would be done by the Government unless it was amply assured by the data secured by the investigating commission.

MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Acting Secretary prior to the final publication.

HUBBARD MOYLAN FEILD, M. Am. Soc. C. E.*

DIED APRIL 11TH, 1920.

Hubbard Moylan Feild was born in Petersburg, Va., on June 4th, 1872. He was the son of Colonel Everard Meade Feild, of old Virginia stock, and a veteran of the Confederate Army, in which he served throughout the Civil War. His mother was Maria Louisa Fox, of Pennsylvania.

Mr. Feild was one of a family of five boys and five girls, being the third eldest of the boys. It is said that he was a real boy, with a strong body and an active mind, much interested in everything pertaining to Indian lore and outdoor life and adventure. He was a leader in his school days and apt in his studies, qualities which acquaintances and comrades of his later life recognized in his maturity.

When he was about eighteen, he received an appointment to the United States Naval Academy, at Annapolis, where he spent about two years. His next experience was on railroad work, in the State of Texas, for the Brazos River Channel and Dock Company, and the Velasco Terminal Railway, during which time he took a special course in the University of Texas.

Shortly after this, Mr. Feild's career in tropical work began in Costa Rica, Central America, where he was employed as Locating Engineer on the Banana River Railway. It was at this time that the well-known developer, Mr. Minor C. Keith, proposed and made a contract for the sanitation of, and municipal works for, Port Limon, Costa Rica. The execution of this work was entrusted to Mr. Feild, who carried it out in a prompt and efficient manner, exhibiting executive qualities which led to further responsibilities entrusted by individuals and companies undertaking that very difficult task of construction, under tropical conditions. He remained in Costa Rica until 1906, as Superintendent and Maintenance of Way Engineer of the Northern Railway.

Mr. Feild's later enterprises included railway building in the Republic of Panama, Honduras, and Cuba, for the United Fruit Company and its allied corporations. He also had the contract for the sanitation of the Port of Almirante in the Republic of Panama.

The writer is intimately acquainted with most of the work done by Mr. Feild and can state that much of it was carried out in the face of the same difficulties which confronted the builders of the railroad across the Isthmus of Panama. Later years, of course, brought relief from the menace of yellow fever with which his earlier labors were involved.

Mr. Feild had the capacity of enlisting the loyalty of his men to the last degree, a quality without which it is impossible to execute tasks amid the dis-

* Memoir prepared by T. Howard Barnes, M. Am. Soc. C. E.

couragements and natural climatic depressions obtaining in these latitudes. The writer, from his intimate acquaintance with Mr. Feild, would bear testimony to the winning and staunch qualities which were part of him. He was always ready to lend a hand, or indeed his purse, when a call of deserving need came to him. He never lost his faith in human nature, and his entire career furnishes an example of optimism which may well be a model for his fellow members.

In his later life, Mr. Feild made his home in New Orleans, La., where his house was ever open to his friends. His last days, though clouded with suffering, were made bright by heroic fortitude and the loving care of his family.

He is survived by his wife, who was Miss Edith Sears, of Boston, Mass., a son and a daughter.

Mr. Feild was elected a Member of the American Society of Civil Engineers on October 1st, 1913.

SIR JOHN KENNEDY, M. Am. Soc. C. E.*

Died October 25th, 1921.

Sir John Kennedy was born at Spencerville, Ont., Canada, on September 23d, 1838, the son of William Kennedy of Dumfriesshire, Scotland. At the age of sixteen, he came to Montreal, Que., Canada, and entered the employ of the late Thomas C. Keefer, Past-President, Am. Soc. C. E., who was constructing the first system of water-works for the city. It was in this practical manner, together with supplemental study, that the boy obtained his knowledge of engineering, but he steadily advanced in his Profession until he became one of its leading authorities on this Continent and was also recognized by the Engineering fraternity abroad. He served as Chief Engineer of the Great Western Railway System, and from 1875 until 1907 as the Chief Engineer of the Montreal Harbor Commission. From 1907, until his death, he was the Consulting Engineer of that body. He was also a member of many important Royal Commissions and was widely consulted in engineering matters.

He was knighted on New Year's Day, 1916, in recognition of his distinguished services, and in March, 1917, McGill University conferred on him the degree of LL. D. In May, 1921, he received the degree of D. C. L. from McMaster University, and these are only a few of the many honors bestowed on him in recognition of his marked ability and sterling qualities.

Sir John was married in 1865 to Miss Louise Scott, of Montreal, and Lady Kennedy, together with two daughters, Lady Ames, of Geneva, Switzerland, and Mrs. H. H. Kennedy, of Montreal, survive him.

At the funeral service, his pastor, the Rev. F. L. Orchard, paid the following tribute of respect and love to the memory of Sir John Kennedy, and his greatness of mind and simplicity of character during a life time of 83 years:

* Memoir prepared by Frederick W. Cowie, M. Am. Soc. C. E.

"There is, as a great scholar has pointed out, a philosophy of history. As we spread the broad expanse of centuries before the mind, strong leaders stand out here and there like great rocks to relieve the dreary wastes and in the shadow of their strength and courage the multitudes have been sheltered from the storms of superstition, vice, and ignorance. There is a sense in which all humanity rests in the shadow of its great lives. * * *

"The natural thing to say first in a tribute to the life of Sir John Kennedy is that he was a genius in the realm of Engineering. The divine and human factors that entered into the endowment of his mind, made him an easy master of the intricate tasks and problems of that calling. It was his playful boast that he began his engineering career at the age of thirteen and indeed he did, at that age, run the engine of his father's mill at Aylmer. He was not a graduate of the schools or universities. Knowledge is acquired, but genius is a gift, and Sir John Kennedy was a genius. Despite his modesty, he recognized his gifts, he regarded them as a holy trust, and from first to last, he sought to use them in the interests of his fellow men. How well he succeeded is indicated by the opening words of an editorial that appeared in yesterday's press: 'Sir John Kennedy is dead, but an imperishable monument remains—the Harbor of Montreal. To him more than to any other man, the country owes its great National harbor'. By his death Montreal lost one of her most widely known and most greatly loved and honored citizens."

At the meeting of the Engineering Institute of Canada on October 27th, 1921, the writer, after the following remarks:

"There are few who have had the opportunity of so intimate and long an engineering or professional connection with the late Sir John Kennedy as the speaker.

"Thirty-eight years ago, it was my good fortune to join the Staff of the Harbor Commissioners, whose Chief Engineer was John Kennedy. During the whole of the thirty-eight years, in connection with the improvements to the River St. Lawrence Ship Channel, the development of public harbors in Canada, and especially the development of the Port of Montreal, it has been my good fortune to be associated with the great Engineer who has to-day been laid to rest.

"In 1886, it was no small thing to be employed under John Kennedy. Until the day of his death, it was no small matter to be professionally associated with the great consulting engineer, whose loss will be a loss to this city and to this country.

"Sir John Kennedy was eminently an engineer. By personality, by courage, by industry, and by skill, he combined all the essentials of that great Profession.

"When it was first my privilege to know him, he was a profound student of engineering, and until the very last he still continued to be so. Many professional men have received inspiration from Sir John Kennedy, and now that he is gone, he has left a monument of integrity, skill, and success, which will be an inspiration to all, and especially to the members of this Institution."

proposed the following resolution:

"*Resolved:* That the Chairman, Executive and Members of the Engineering Institute of Canada deeply mourn the death of Sir John Kennedy, but that they feel consolation in the thought that their late friend and confrère was spared to a ripe old age, to give the benefit of his sound advice and counsel to the Institute, as well as to the members personally. The Montreal Branch of the Institute is desirous of putting on perpetual record some of the notable acts of its late friend, both in his public and private life, so that his career will be an inspiration to those who come hereafter:

"Sir John Kennedy was eminent as an engineer, both on the Continent of America and abroad, and his sound professional judgment was invoked on many occasions and his suggestions carried out to a successful issue. In the field of hydraulic engineering, mechanical, and construction problems, his genius was outstanding.

"Notable among his successes was the deepening of the River St. Lawrence and the development of the Port of Montreal, under the Harbor Commissioners. The manner in which he carried out the improvements to the River St. Lawrence Ship Channel is outstanding, and the methods he adopted and the mechanical means to that end are still, in many particulars, followed by his successors.

"In paying this last tribute to our departed friend and counsellor, we cannot forget the part he took at the inception of this Society, and the constant attention he gave to its problems and welfare.

"As a citizen he was beyond criticism, and although he took no active part in civic government, his advice was often sought and freely given. His Christian character is without reproach, and his domestic relations were of the happiest.

"The members of the Montreal Branch of the Institute offer their heartfelt sympathy to the family and relatives, and pray that consolation will be afforded to them by dwelling on the record left by him after a long and successful career. To the partner of his life's joys and sorrows, we especially tender our sympathy, and trust that Lady Kennedy will yet be long spared to be a comfort to her bereaved family."

Sir John Kennedy was elected a Member of the American Society of Civil Engineers on September 1st, 1875, and served as a Director of the Society from 1898 to 1900.

JOHN CHARLES QUINTUS, M. Am. Soc. C. E.*

Died November 27th, 1921.

John Charles Quintus, the son of Jacob and Catherine Quintus, was born in Sheboygan, Wis., on October 8th, 1856. His parents were Hollanders, who came to the United States in 1847, his maternal ancestors having been French Huguenots who fled to Holland to escape religious persecution.

In 1858, the family moved to Grand Rapids, Mich., where Mr. Quintus received his elementary education. He entered the University of Michigan in 1875, and was graduated in 1879, with the degree of Mining Engineer.

He practiced mining engineering for about one year after leaving college, and then entered the Government service with the Mississippi River Commission at St. Louis, Mo., and for about six years was employed principally on triangulation work on the Mississippi and Missouri Rivers. In 1886, he was transferred to the U. S. Lake Survey, and was stationed at Grand Rapids, Mich. In 1887, he began work in the Buffalo District, Engineer Department at Large, at Erie, Pa., where he remained for eight years, in local charge of harbor improvement work, consisting of dredging, pier and jetty construction, and shore protection work.

* Memoir prepared by Lynn L. Davis, M. Am. Soc. C. E.

In 1895, he was transferred to Buffalo, N. Y., and shortly after the transfer became Principal Assistant Engineer of the Buffalo District, in which position he served until February, 1915. On February 26th, 1915, Mr. Quintus was promoted, and appointed Assistant Engineer in the office of the Division Engineer, Lakes Division, at Buffalo, N. Y., aiding in the supervisory charge of all the harbors and connecting channels of the Great Lakes and tributaries, from Duluth, Minn., to Ogdensburg, N. Y., in which position he served until his death.

On December 24th, 1886, Mr. Quintus was married to Miss Nellie Nellis, of Mount Clemens, Mich., who, with one daughter, Katrina, survives him.

Mr. Quintus designed the rubble mound breakwater for the extension of the Buffalo Breakwater System to Stony Point. This structure, with its closely paved top of large stone and long sloping lake face, is and will remain a monumental structure. He also designed the Black Rock Ship Lock and the steel sheet-pile coffer-dam that was used in the construction of the lock. It is believed that this was the first time that this type of square, clay-filled, connected pockets of steel sheet-piling was ever used for a coffer-dam. A modified form of this type was used later for raising the U. S. S. *Maine,* in Havana Harbor, and has subsequently been used quite extensively where limited room makes an expensive type of dam necessary.

Mr. Quintus was a member of the Chi Psi Fraternity and the Westminster Club, and, at one time, he was also a member of the University Club of Buffalo, but being a home-loving man, he did not maintain his membership in this club.

He was a quiet, kindly man who, though decided in his opinions and exact in his methods, was never harsh in his treatment of his subordinates. He was remarkably well versed in the laws and regulations pertaining to the Engineer Department at Large, both in letter and spirit, as well as in the design and construction of work for the improvement of the harbors and connecting channels of the Great Lakes; and this knowledge was of great value to his superiors, to whom he was thoroughly loyal, faithfully carrying out their ideas, even though at times they were at variance with his own, and was highly esteemed by all of them.

His unswerving fidelity to the Department which he served for more than forty years can be said to be his outstanding characteristic. In the words of one of the Senior Colonels of the Corps of Engineers, with whom Mr. Quintus had served continuously for the past eleven years, "He was a most valuable public servant."

Mr. Quintus was elected a Member of the American Society of Civil Engineers on January 2d, 1889.

ANSON MORSE BLENUS, Assoc. M. Am. Soc. C. E.*

Died January 5th, 1922.

Anson Morse Blenus was born at Worcester, Mass., on July 2d, 1873, where he received his common and High School education. Later, this was supple-

* Memoir prepared by J. R. Berberick, Esq., New York City.

mented by special courses at the Mechanics Institute and at Columbia University.

His early days were spent in the employ of contractors as Time Clerk, Material Clerk, and Foreman.

During the Spanish War, Mr. Blenus served aboard a gunboat of the United States Navy as Assistant Engineer. In the following year, he went to South Africa and, during the Boer War, served with the British forces, in the Royal Engineers, developing and operating the emergency water supply for the garrison during the siege at Ladysmith.

In the following year, Mr. Blenus returned to New York City and entered the employ of the George Mulligan Company, which firm sent him to Capetown, South Africa, where he was in charge of its work for several years.

In 1909, he entered the employ of W. J. Jones, Civil Engineer, and took part in the power development and the construction of the underground conduit system for the City of Reading, Pa. During this period, he also had charge of the underground system for the New York, Westchester and Boston Railroad Company.

During 1912-14, Mr. Blenus was employed in the capacity of Designer in the offices of the Pearson Engineering Corporation, and took part in the Sorocaba (São Paulo), Brazil and Ebro (Spain) Projects.

In 1914, he entered the Engineering Department of the Interborough Rapid Transit Company on the Manhattan Elevated Improvement, and in 1917, he joined the Construction Division of the Texas Company as Designing Engineer.

He entered the employ of the Foundation Company, in 1918, as Designer and, in 1920, joined the Canadian Engineering Agency, Incorporated, in a like capacity. He held this position at the time of his death from toxic poisoning supervening a fever which he had contracted while in South Africa.

Mr. Blenus was married in October, 1905, to Clara Mabel Baker who, with a daughter, Madeline L., survives him.

He was a man of pleasing personality and social disposition, who made friends easily and was liked and respected by all his associates.

Mr. Blenus was elected an Associate Member of the American Society of Civil Engineers on July 6th, 1920.

FRANKLIN LINCOLN GIBBONEY, Assoc. M. Am. Soc. C. E.*

Died November 20th, 1921.

Franklin Lincoln Gibboney was born at Wytheville, Va., on July 15th, 1882. He received his early education in the public schools of his native town, and was graduated in 1904 from the Virginia Polytechnic Institute, Blacksburg, Va., with the degree of Bachelor of Science in Civil Engineering.

In May, 1904, he accepted the position of Assistant Engineer of the City of Roanoke, Va., in which capacity he had charge of street and sewer improvements for that city.

* Memoir prepared by W. S. Fallis, M. Am. Soc. C. E.

In September, 1909, Mr. Gibboney was elected City Engineer of Roanoke, and was re-elected as such for nine consecutive terms, until 1918. He was, also, for a short time afterward, connected with the State Highway Commission of Virginia.

In 1919, he was appointed as Material Engineer of the State Highway Commission of North Carolina, which position he held at the time of his death at Charlotte, N. C., on November 20th, 1921.

He is survived by his wife and one son, William, and by his parents and two brothers and two sisters. He was of a happy disposition and drew around him a wide circle of friends who mourn his loss.

Mr. Gibboney volunteered for service and was commissioned a First Lieutenant in the Engineering Department of the American Expeditionary Forces, having been ready for duty when the Armistice was signed.

He was a consistent and faithful member of the Protestant Episcopal Church, and was prominent in Fraternal circles. He was a member of the American Association of Engineers and of the North Carolina Society of Civil Engineers.

Mr. Gibboney was elected an Associate Member of the American Society of Civil Engineers on October 31st, 1911.

RICHARD TUGGLE GOODWYN, JR., Assoc. M. Am. Soc. C. E.*

Died November 8th, 1921.

Richard Tuggle Goodwyn, Jr., was born at Montville, near Aylett, Va., on June 23d, 1892, the son of Richard Tuggle Goodwyn and Sally (Aylett) Goodwyn, both of Virginia.

Trained in the preparatory schools of St. Charles Military Academy and Rugby Military School at St. Charles, Mo., he entered the University of Georgia in 1909 and was graduated in 1913, with the degree of Bachelor of Science in Civil Engineering and with a notably fine scholastic record.

As an undergraduate, Mr. Goodwyn held commissions as Second Lieutenant, Company F (1912), and Captain, Company D, in the University Battalion. He was Secretary-Treasurer of the Engineering Society, a member of the Sine and Tangent Club, Editor in Chief of the *Engineering Annual*, and Vice-President of the Senior Class.

In the fall of 1913, Mr. Goodwyn began his professional career as Civilian Assistant in the United States Engineer Corps, at Brunswick, Ga., on river and harbor work; and shortly afterward accepted service as Valuation Engineer with the Interstate Commerce Commission, with headquarters at Chattanooga, Tenn.

He remained in this service, with rapid promotion, until the United States entered the World War. His first effort to enlist as a volunteer in the Army was barred by an unfavorable medical report; but, by further effort, he secured a transfer as a Private into the Fifth Regiment, Engineers, U. S. A., and was shortly afterward commissioned as Second Lieutenant of Engineers.

* Memoir prepared by C. M. Straban, M. Am. Soc. C. E.

Having received his discharge from the Army in December, 1918, Mr. Goodwyn resumed his position with the Interstate Commerce Commission. In January, 1920, he was appointed by the State Highway Department of Georgia as Division Engineer in charge of the State highways in the Eighth Congressional District, with headquarters at Athens, Ga. He filled this position with exceptional efficiency until his tragic death on November 8th, 1921. While in the discharge of his duty, he was accidentally killed, his automobile having overturned from an embankment, on a dark rainy night, at the Alcovy River Bridge, near Covington, Ga.

He was a member of the American Association of Engineers and the Society of Military Engineers. He was associated with the Chattanooga Branch of the American Legion, and was a faithful and active member of Emmanuel Church, Athens, Ga.

Young in years, Mr. Goodwyn had, to a singular degree, won the confidence of his professional associates and of the public with whom his large responsibilities brought him in contact.

Under the most difficult post-war conditions, charged with the detailed planning and construction of about 500 miles of main State highways, involving large expenditures of funds arising in co-operation from the Federal Government, from various counties, and from the State of Georgia, he established a reputation for sound engineering and executive judgment, for untiring energy and singleness of purpose, for scrupulous integrity and effective performance which exemplify the finest and best ideals of the Engineering Profession.

Distinguished by a fine intellect and high personal character, by a pleasing, quiet, but firm bearing, by a habit of thorough mastery of facts and details, by an unswerving sense of duty, by a sympathetic understanding of men and power of leadership, by an unassuming but controlling religious spirit, Mr. Goodwyn leaves a record of professional and personal worth which keenly emphasizes the sadness of his untimely death and the loss to his chosen profession.

Mr. Goodwyn was elected an Associate Member of the American Society of Civil Engineers on September 12th, 1921.

RALPH EWART ROBSON, Assoc. M. Am. Soc. C. E.*

DIED OCTOBER 14TH, 1921.

Ralph Ewart Robson was born in Sioux City, Iowa, on June 27th, 1886. His father was John Ewart Robson, an Engineer and Contractor, whose sudden death in 1899 placed on the boy the duties of contributing to the family support and securing an education for himself. Principles of industry and activity had been early inculcated in him by both his parents, and these principles he adhered to with unflagging energy to his death.

The boy attended Grammar and High School in Sioux City, and was graduated from the latter in 1904, as President of his Class. Although he

* Memoir prepared by Thomas H. Means, M. Am. Soc. C. E.

was far from robust as a lad, he found no task too difficult, no labor too arduous, as long as it meant a continuance of his education. After his graduation, he joined a surveying party with the late Brig.-Gen. (then Col.) H. M. Chittenden, U. S. A. (*Retired*), M. Am. Soc. C. E., and spent the summer and early fall in Yellowstone National Park. He was ill after his return and, in the spring of 1905, his health not being good, he went to California. After more than a year of hard work in various parts of the State, he entered the University of California, from which he was graduated in 1911, with the degree of B. S. in Civil Engineering. He was a member of the Delta Tau Delta Fraternity.

To help out his finances and enable him to continue at college, Mr. Robson went to Alaska in the spring of 1908, with the Fremont-Morse party to establish the boundary between the United States and Canada. While still in college, he wrote and had accepted for publication in various periodicals, articles on the work in Alaska, illustrated with his own photographs.

After his graduation from the University of California, Mr. Robson entered the employ of Sloan and Robson and while with this firm worked on designs for water and sewer systems for various California municipalities. He was also Superintendent or Engineer in Charge of several projects, at Fullerton, Anaheim, Tulare, and other places.

In January, 1914, he became interested in the plan of the Atascadero Colony near Paso Robles and there, under H. T. Cory, M. Am. Soc. C. E., who was Chief Engineer, he stayed two years, becoming Resident Engineer of the project before he left in 1916.

Maintaining the interest in military affairs which began when he was a child, Mr. Robson attended the first Civilian Training Camp held at Monterey in July, 1916. In the late summer of the same year, he went to Utah for the Utah Copper Company, to superintend the construction of a leaching plant. He returned to California and, in January, 1917, went to the Anderson-Cottonwood Irrigation District, where he remained until May of that year, when he entered the First Officers' Training Camp, in the Engineering Section, at the Presidio of San Francisco. The Engineers were transferred to Vancouver Barracks, Washington, to complete their course, and there Mr. Robson was graduated, in August, 1917, with the rank of Captain of Engineers and was at once assigned as Commanding Officer of Company E, 316th Engineers, at Camp Lewis, Wash. He was training troops and preparing for overseas duty until June, 1918, when with the remainder of the regiment, together with all of the 91st Division, he left for France, where his company joined the American Expeditionary Force and received the final training which was to prepare it for active combat work in the front line.

Of Mr. Robson's part in the World War, a fellow officer, Captain Ross Mahon, has the following to say:

"From the day on which Company E was organized, Ralph Robson evidenced the characteristics and attributes which are required for the highest type of American officer. Through the long, hard weeks of the early training period, he applied himself untiringly to the work of building up the most efficient kind of an organization. Night and day he labored to overcome the difficulties which presented themselves. No detail was so small or un-

important that it could be overlooked. * * * All who knew him realized that Ralph Robson was, perhaps, the most sincere and thoroughly in earnest officer of the regiment. * * * Again, for six weeks the hard grind of training continued on French soil and the love and loyal devotion that Captain Robson received from the men and officers under his command, did more, perhaps, than any other one thing to produce an efficient fighting unit from the 250 untrained men who had reported to him twelve months earlier.

"Captain Robson, with his company, took part in the St. Mihiel Offensive and the Meuse-Argonne Offensive, after which the 316th Engineer Regiment, with the 91st Division, was shifted to the Flanders front. On October 31st, and just before his company went into the front line in the Ypres-Lys Offensive in Belgium, Robson was detached from Company E and, although still a Captain, was given command of the First Battalion during the interval when it was actively engaged in combat, from November 1st to November 10th, 1918.

"On November 10th, he received his promotion to Major and from that date until the final mustering out of service in May, 1919, he retained command of his battalion. * * *

"All who knew the man through those two years have only the highest words of praise for Major Robson. His devotion to duty, his absolute sincerity, his love and regard for his fellow men, his square dealing, and his unfailing good nature, will live long in the memories of his comrades in arms."

The award of the Belgian War Cross by the Belgian Government was made to Major Robson for the following services rendered, the citation reading as follows:

"On October 31, 1918, and November 1, 1918, he handled his Battalion in a very efficient manner in the reconstruction of roads and bridges in the vicinity of Waereghem, Belgium, permitting the early advance of the Divisional Trains and Artillery."

After his return from France, Major Robson became Manager of the American Seedless Raisin Company's vineyard near Livingston, Calif., where his tireless energy and ambition enabled him to perform his duties in the most satisfactory manner, study and review his French, and take an Extension Course in Viticulture and one in Military Tactics.

In February, 1921, he became associated with the Cope Rand Means Company, in San Francisco, Calif., and made his home in Berkeley. He put forth all his efforts toward making a place for himself in the engineering world, making every minute count, studying irrigation engineering, writing a paper on the "Work of the American Divisional Engineer in France," and renewing college friendships and making new ones.

In September, 1921, he was appointed Resident Engineer of the Tule and Baxter Creek Irrigation Districts, in Lassen County, California. While performing his duties for the Irrigation Districts, he was killed instantly, on October 14th, 1921, when the car he was driving ran into a guy wire which had been stretched from a haystack across a public road.

The news of his sudden death came as an appalling shock to his host of friends in the United States, France, and Belgium. It seemed a queer turn of Fate that a man so vital, so forceful, who had faced death on a battle front and come through unscarred, should lose his splendid life in such an accident.

His magnificent physique, won by his outdoor work and his clean living, made him an ideal figure of the best type of American soldier, and to those who saw him in his unform, he will be remembered as Major Robson, the tall, fine-looking officer with his erect carriage and soldierly bearing, his rare personal magnetism, and, at the end, his military funeral in Berkeley where his brother officers performed their last service for their beloved comrade. To most of his friends he will always be "Ralph Robson", which is as he would have it. To all who knew him, he was an unforgettably gracious friend.

> "E'en as he trod that day to God so walked he from his birth,
> In simpleness and gentleness and honour and clean mirth."

On June 30th, 1913, Mr. Robson was married in Berkeley, Calif., to Miss Barbara L. Reid, a classmate at the University. He is survived by his wife, his mother, two sisters, and a brother, F. T. Robson, Assoc. M. Am. Soc. C. E. He was a member of the Paso Robles Lodge of Masons.

Mr. Robson was elected a Junior of the American Society of Civil Engineers, on October 3d, 1911, and an Associate Member on June 3d, 1915.

ELIOT NICHOLS SMITH, Assoc. M. Am. Soc. C. E.*

Died February 17th, 1921

Eliot Nichols Smith was born in East Hartford, Conn., on August 6th, 1878, of English ancestry. His father was John B. Smith and his mother, Lucy Nichols Smith. The family was long settled in New England, and Eliot Smith's youth was spent in Connecticut. A great-grandfather named West served in the Revolutionary War; he entered as a private, was afterward made a Sergeant, and, finally, became a surgeon.

Both Eliot Smith's grandfathers were ministers. Grandfather Smith preached only occasionally, being interested in medicine and in farming as well. Grandfather Nichols was a Congregational minister in Connecticut for many years. His salary was only $450 a year, so it was necessary not only that he should practice rigid economy, but that he should raise as much as possible on his few acres. Eliot Smith was thought to resemble this Grandfather Nichols. He had the same instinctive hatred of waste, an equally strong love of hospitality, and a steady, practical intelligence.

His father, John B. Smith, did not have much formal education, but he studied at the Sheffield Scientific School for a few months. He was always prominent in Sunday School and temperance work. He was eager, impulsive, full of new and old ideas, and always bursting with his passionate beliefs. For most of his life, he was a market gardener and had fine orchards where the boys of the family worked during the summer, not always, perhaps, to their complete satisfaction. Indeed, summer was to Eliot Smith, the oldest son, distinctly difficult. He was like his mother in temperament, and the bond between them grew constantly stronger.

* Memoir prepared by James F. Sanborn and Robert Ridgway, Members, Am. Soc. C. E.

In the family group there were six girls and three boys, and many were their good times, with games, inpromptu entertainments, and music. One of the sisters, Laura, went as a missionary to South Africa, and a brother, Harry James, was always interested in writing. He became a well known playwright, and was killed during the World War, while in Red Cross Service.

With a nature strong and fine like that of Eliot Smith, the influence of the different members of the family group with interests so diverse, was not so much specific, as a general broadening of outlook.

His common school education was received at the Model School connected with the State Normal School in New Britain, Conn., and he prepared for college at Williston and afterward at Oberlin Academy, and was graduated from Oberlin College in 1900. At Oberlin, he was able to satisfy, somewhat, his deep love for music. He sang in the choir, and was the leader of the College Mandolin Club. His happiest student days, however, were those at the Lawrence Scientific School, at Harvard, from which he was graduated with honors in 1904.

Mr. Smith's studies at Harvard were interrupted in 1901, when he accepted a railroad position in Pittsburgh, Pa. He contracted typhoid fever while on this work, from which his recovery was so slow that a trip to Colorado was deemed advisable. His brother Roy, who was a student at that time at Colorado College, writes:

"During my Freshman year I was greatly thrilled at Eliot's visit, you may be sure. We lived together in the same room some of the time, getting our own breakfast, and went off with one or two kindred spirits on long tramps to the various mountains and canyons in the neighborhood. He gained much in health, got a little valuable surveying experience, and returned to Harvard to finish up his course."

His return to Harvard was characteristic. "I do not think I will ever make any more money by going back", he said, "but I do think my life will be better worth living", and he never regretted his decision.

Herbert M. Hale, M. Am. Soc. C. E., writes:

"I first knew Eliot intimately when he and I were Assistant Instructors in surveying at the Engineering Camp at Squam Lake. He had a way with him that made the students under his care really like the work. That was just prior to our Senior year."

The following is quoted from a letter by Dean G. Edwards, M. Am. Soc. C. E.:

"Eliot was graduated with our class in Civil Engineering in 1904 and very pleasant relations were established among us in Cambridge. Eliot took the camp courses at Squam Lake in the summer of 1903, and I remember particularly, as a great event, the long hike and climb of Mt. Whiteface over the 4th of July of that year. Eliot was one of our party of twelve bunking with us in a barn one night before the Fourth, and carrying his share of the baggage and enduring the blistered feet with the good nature that made the party a success and the occasion memorable."

After his graduation from Harvard in 1904, Mr. Smith went to New York City and began work as an Assistant Engineer on the new subways, remaining

in the service of the Rapid Transit Railroad Commission until the spring of 1906. Mr. Edwards writes:

"A group of us met again in New York after graduation in August 1904, when we entered the employment of the Rapid Transit Commission. Seven of us, Eliot Smith, Sprague, Hogan, Hale, Hanavan, Gilman, and myself leased an apartment on 118th Street, opposite Columbia and lived there together for one year." * * * "He was a lover of music—introduced me to the opera—and played the violin in our 'apartment orchestra', with Hale and Gilman as assisting artists, back in 1904 and 1905."

In 1906, Mr. Smith entered the employ of the New York Board of Water Supply and continued on the Catskill Aqueduct work until 1914. The following is quoted from a letter by John P. Hogan, M. Am. Soc. C. E.:

"Eliot was one of the few who passed all three examinations for the Board of Water Supply with flying colors; he was, therefore, one of the first to go up on the Board of Water Supply work, and if my memory is not at fault, was with Sanborn both at Hurley and at High Falls. He was then in New Paltz for a while, and was graduated from there to the Poughkeepsie office, coming back to High Falls as my assistant after White left. He was a very hard worker and had an exceptionally keen and analytical mind. He was very actively concerned in the location of the Esopus cut-and-cover on the estimating side. We all know that he was personally of a very fine character, absolutely honest, both morally and mentally, with a very high ethical standard. He could be counted on for not only official loyalty, but also for very strong personal loyalty. He had pleasant manners, a ready wit, and keen sense of humor. My associations with him were always most pleasant, and I learned to admire and respect his high gifts of character and intellect."

On this work, Mr. Smith was at first engaged as Assistant Engineer on location studies for the Esopus and Wallkill Divisions and was stationed at New Paltz, N. Y., for about a year. He was then transferred to the Department Office, at Poughkeepsie, N. Y., and was employed on a great variety of problems concerned with the location studies and estimates and the preparation of information for the construction contracts for the sixty miles of aqueduct of the Northern Aqueduct Department.

In 1911, Mr. Smith was assigned to the Esopus Division as Assistant to the Division Engineer, and remained in this position about a year. During several months of this period, he was in charge of the engineering work of the Division, which included the first twelve miles of the Aqueduct below the Ashokan Reservoir and which cost about $9 000 000 to construct. On the practical completion of the work on this Division in 1912, Mr. Smith was transferred to the office of the Northern Aqueduct Department, which had been moved from Poughkeepsie to Cornwall-on-Hudson, acting as Assistant to the Department Engineer. During the time he was in Cornwall, practically all the work in the Northern Aqueduct Department was brought to a successful completion. The writers are familiar with Mr. Smith's ten years on the Catskill Aqueduct and know how much of himself he put into this work.

In 1914, feeling that the work of the Board of Water Supply was nearing completion, and that his best efforts would be called forth by some new piece of work in engineering, Mr. Smith resigned from the Board, and took up his residence in Nutley, N. J. For several months, he was engaged on the prepara-

tion of contracts and designs for a number of projects in the vicinity of New York City, notably a new pipe line for Jersey City, N. J.

During these years, he began more and more to identify himself with the first interests of the community in which he lived, a longing which his constant change of residence heretofore, had given little opportunity to satisfy. He became a member of the Board of Trade of Nutley, was for four years leader of a troop of Boy Scouts connected with Grace Protestant Episcopal Church, building it up from a sparse, uninterested membership to a flourishing organization for town service, and served as Treasurer on the Campaign Committee which helped to elect Emil Diebitsch, M. Am. Soc. C. E., as Mayor of the town.

Mr. Smith was appointed to be the first Town Engineer of Nutley, on July 10th, 1916, and served the community in that capacity for more than three years. He was placed at the head of the newly created Bureau of Engineering and had responsible charge of the inspection of buildings under construction and the issuance of building permits, the maintenance of roads and sidewalks, and the laying of all new pavements, the maintenance of the water system, the extension of mains, the making of house connections and the reading of meters, and the construction of a sewer system covering the entire town and estimated at that time to cost $350 000. Starting with less than nothing, with patience, perseverance, and industry, Mr. Smith soon systematized the activities placed in his charge and developed an effective organization which functioned intelligently and economically. By introducing the latest methods and processes in the repair and resurfacing of the macadam roads, he greatly improved the highways without increasing the cost of maintenance.

The work of municipal engineering, with all its complex phases, was particularly appealing to Mr. Smith. He liked the personal contact with fellow townsmen, the frequent necessity of delving into legal matters, and the diverse municipal questions connected with economics, a study in which he was particularly sound. A great aspiration of his was to serve some community in the capacity of City Manager.

In 1919, to the regret of the Mayor and all others acquainted with his work, Mr. Smith resigned as Town Engineer and moved to Lisbon, N. H., where he bought a home and engaged in the wood-turning business.

He was married in 1909 at Keene, N. H., to Miss Margaret Pollard who was an Instructor of English at Vassar College, and a woman of unusual quality. They had four children, two girls and two boys.

Mr. Smith's sister Edith writes:

"There was a singular unity about him, an utter freedom from self-consciousness in all he did. If it was his job, he did it with a uniform standard of excellence and thoroughness."

> "He scarce had need to doff his pride or slough the dross of earth,
> E'en as he trod that day to God so walked he from his birth,
> In simpleness and gentleness and honor and clean mirth."

Mr. Smith was elected a Junior of the American Society of Civil Engineers on April 2d, 1907, and an Associate Member on June 30th, 1910.

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"CORE STUDIES IN THE HYDRAULIC-FILL DAMS OF THE MIAMI CONSERVANCY DISTRICT." CHARLES H. PAUL.

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PROGRESS REPORT OF THE SPECIAL COMMITTEE TO CODIFY PRESENT PRACTICE ON THE BEARING VALUE OF SOILS FOR FOUNDATIONS, ETC.

CURRENT PAPERS AND DISCUSSIONS

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

VOL. XLVIII—No. 4

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April, 1922

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PROCEEDINGS

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AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XLVIII—No. 4.

APRIL, 1922

Edited by the Secretary, under the direction of the Committee on Publications.

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American Society of Civil Engineers

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The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day. Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

HEADQUARTERS OF THE SOCIETY—33 WEST THIRTY-NINTH STREET, NEW YORK.

TELEPHONE NUMBER........................7100 Longacre.
CABLE ADDRESS........................"Ceas, New York."

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AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

SOCIETY AFFAIRS

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MINUTES OF MEETINGS

OF THE SOCIETY

April 5th, 1922.—The meeting was called to order at 8:15 P. M.; Francis Lee Stuart, M. Am. Soc. C. E., in the chair; C. E. Beam, acting as Secretary; and present, also, 128 members and guests.

The minutes of the meeting of March 1st, 1922, were approved as printed in *Proceedings* for March, 1922.

The following deaths were announced:

FRANK EDWARD BISSELL, of Cleveland, Ohio, elected Junior, April 2d, 1884; Member, September 2d, 1891; date of death unknown.

HARRY DEAN BUSH, of Baltimore, Md., elected Member, May 2d, 1888; died March 15th, 1922.

FRANK CHITTENDEN OSBORN, of Cleveland, Ohio, elected Member, October 3d, 1888; died January 31st, 1922.

Lingan Strother Randolph, of Baltimore, Md., elected Member, January 2d, 1890; died March 7th, 1922.

John Richard Savage, of New York City, elected Member, June 7th, 1905; died February 25th, 1922.

Edgar True Wheeler, of Los Angeles, Cal., elected Member, December 7th, 1904; died March 2d, 1922.

Joseph Wood, of Pittsburgh, Pa., elected Member, April 1st, 1874; died March 4th, 1922.

Robert Max DeGarmo, of Cocoanut Grove, Fla., elected Associate Member, November 4th, 1914; died February 14th, 1922.

William Arthur Lafler, of Rochester, N. Y., elected Associate Member, May 4th, 1909; died January 19th, 1922.

The election of the following candidates on April 3d, 1922, was announced:

As Members

Louis Milton Adams, Galveston, Tex.
Walter Sidney Bobo, Clarksdale, Miss.
Ora Bundy, Ogden, Utah
Charles Dwight Curtiss, Washington, D. C.
James Hopkins Dousman, Kansas City, Mo.
Robert James Hallidy, Delhi, India
Forrest Shepherd Harvey, Baltimore, Md.
William Pierce Hoppin, Chicago, Ill.
Henry Baker Lynch, Los Angeles, Calif.
Umberto Ernesto Martini, Rome, Italy
James Edward Pirie, Ballinger, Tex.
Porter Johstone Preston, Yuma, Ariz.
Eugene Schaub, Logan, Utah
Albert Maser Traugott, Norfolk, Va.
August John Werner, Los Angeles, Calif.
Frank Clinton Wight, New York City

As Associate Members

Harold Ward Barker, Detroit, Mich.
Carl William Beck, Bellevue, Pa.
Claud Francis Blain, Sydney, New South Wales, Australia
Earnest Boyce, Lawrence, Kans.
Francis Aloysius Boyle, New York City
Sigmund Braverman, Akron, Ohio
Kenyon Harrington Clark, San Luis Obispo, Calif.
Robert Henry Clinger, Dallas, Tex.
Albert Edward Cummings, Chicago, Ill.
Ernest Ambrose Dockstader, Boston, Mass.
John Arnold Donald, Wichita Falls, Tex.
Robert Sewall DuBois, Denver, Colo.

Bowie Griffith Etchison, Charleston, W. Va.
George DeVore Fairtrace, Dallas, Tex.
John Sherrod Fenner, Kaufman, Tex.
Henry Alden Foster, South Orange, N. J.
Olaf Froseth, Chicago, Ill.
Charles Henry Gaedcke, Elizabeth, N. J.
John Henry Gaynor, New York City
Harry Simmerman Gibboney, Atlanta, Ga.
Charles Riviere Goodman, Orange, Tex.
Harold Moffet Gould, Detroit, Mich.
Chesleigh Gray, Indianapolis, Ind.
Clyde Elbert Healy, San Francisco, Calif.
Henry William Hemple, Washington, D. C.
George Earl Hill, Carroll, Iowa
Alfred Turrill Hopkins, Detroit, Mich.
William Davis Howren, Amarillo, Tex.
Leonard Augustus Idle, Oklahoma, Okla.
Lawrence Lee Jemison, Charleston, W. Va.
Wardell D. Johnston, Waterloo, Iowa
Ernest Lester Jones, Washington, D. C.
George Van Sise Keely, Port of Spain, Trinidad
John Lonsdale Lamb, Brooklyn, N. Y.
Edward Gustaf Larson, White Plains, N. Y.
William Willson McClevy, Roanoke, Va.
John Alexander McLean, Crookston, Minn.
Henry Louis Maurer, New Bremen, Ohio
Ralph Peter Melendy, Wichita Falls, Kans.
Nathan Wilson Morgan, Denver, Colo.
Earle Hedderich Morris, Bismarck, N. Dak.
Edward Towler Murchison, Chicago, Ill.
Stewart Smith Neff, Maracaibo, Venezuela
James Blaine Newman, Ann Arbor, Mich.
Reeves Jose Newsom, Lynn, Mass.
Frank Benjamin Ogle, Coleman, Tex.
Harry Connelly Orr, Charleston, S. C.
Willard Eastman Simpson, San Antonio, Tex.
George James Stein, Miami, Okla.
Nelson Stone, Syracuse, N. Y.
Frank DeWitt Talbot, Sacramento, Calif.
Lloyd Webb Taylor, Decatur, Tex.
Tinph Weitson Tu, Harbin, China
Joseph Houston Wasson, Lansing, Mich.
Warren Gardner White, Tipton, Iowa
Frank Day Wilcox, Los Angeles, Calif.
Robert Wilson, Victoria West, Cape Colony, South Africa
Pond Sheppon Wu, Shanghai, China

As Affiliates

Malcolm Dunbar Riker, Dover, N. J.

As Juniors

Carl Osborn Barton, Detroit, Mich.
Karl Ferdinand Biehler, Los Angeles, Calif.
Manuel de Cominges Tapias, Vigo, Spain
William Benedict Delehanty, Edgewater, N. J.
Simon Wilke Freese, Fort Worth, Tex.
John Charles Gebhard, New York City
Joseph Henry Glidden, Ellensburg, Wash.
Benjamin Sheppard Goldman, Brooklyn, N. Y.
Casimiro Osvaldo Gomez Rodriguez, Santo Domingo, Dominican Republic
Francis Kennedy Green, Middleburg, Va.
James Horace Hendry, Hartford, Conn.
Harold Calvin Hufford, Liberty, Mo.
Otto Lauterhahn, Trenton, N. J.
Ralph Alton Moyer, Ames, Iowa
Percy Vivian Pennybacker, Shamrock, Tex.
Rowland Cuthbert Robin, Gilberton, South Australia
Benjamin Saltzman, Brooklyn, N. Y.
Horace Adali Sawyer, Breckenridge, Tex.
John Allen Scoville, Mare Island, Calif.
Chilton Austin Wright, New Rochelle, N. Y.

The transfer of the following candidates on April 3d and 4th, 1922, was announced:

From Associate Member to Member

Edward Anderberg, New York City
Joseph Edgar Bell, Butte, Mont.
Joseph Brandly Converse, New Orleans, La.
William Owen Cotton, Idaho Falls, Idaho
John Whitfield Cowper, Buffalo, N. Y.
Lynn Crandall, Mackay, Idaho
Harry Jocelyn Dignum, Baragua, Camaguey, Cuba
Nathan Washington Dougherty, Knoxville, Tenn.
Forrest Faye Frazier, Manhattan, Kans.
Francis Eugene Freeland, Nashville, Tenn.
George Stevens Hinckley, Redlands, Calif.
William Whitehead Hurlbut, Los Angeles, Calif.
George Walther Koss, Des Moines, Iowa
John Francis Laboon, Pittsburgh, Pa.
Claude Milton Lambe, Raleigh, N. C.
Frank Ray Lanagan, Albany, N. Y.

Robert John Ross, Hartford, Conn.
Walter Ellsworth Rowe, New Orleans, La.
Charles Wesley Schubert, Cleveland, Ohio
Thomas William Secrest, Anchorage, Alaska
William Albie Van Duzer, Harrisburg, Pa.
Emanuel Louis Verveer, New York City
Martin Wallace Watson, Topeka, Kans.
George Philip Winn, Nashua, N. H.

From Junior to Associate Member

Edwin Ryan Akers, Havana, Cuba
Charles Wightman Barber, Washington, D. C.
Leo Francis Brown, Brooklyn, N. Y.
George Dashiell Camp, Calcutta, India
Paul Francis Critz, Ames, Iowa
Nasri Suleiman Fuleihan, Jerusalem, Palestine
Lawrence Scofield Holmboe, Oklahoma, Okla.
John Lowery, Jr., Ambridge, Pa.
William Sing-Chong Pung, Shanghai, China
Alvin Christian Rasmussen, Indianapolis, Ind.
Oswald Speir, Jr., Visalia, Calif.
Norman Kenneth Wilson, Milwaukee, Wis.

A paper by Gustav Lindenthal, M. Am. Soc. C. E., entitled "The Continuous Truss Bridge over the Ohio River at Sciotoville, Ohio, for the Chesapeake and Ohio Northern Railway", was presented by the author, who illustrated his remarks with lantern slides. The subject was discussed by Messrs. Francis Lee Stuart, T. Kennard Thomson, H. H. Quimby, Theodore Belzner, G. E. Beggs, and H. W. Troelsch. A written discussion on the subject by C. A. P. Turner, M. Am. Soc. C. E., was also received.

On motion, duly seconded, a resolution of regret at the great number of deaths announced was adopted.

On motion, duly seconded, a vote of thanks was extended to Mr. Lindenthal for his paper.

Adjourned.

MINUTES OF MEETINGS OF SPECIAL COMMITTEES TO REPORT ON ENGINEERING SUBJECTS

Minutes of Meeting of Special Committee on Stresses in Railroad Track

March 14th, 1922.—The meeting was called to order at the Congress Hotel, Chicago, Ill. Present: Messrs. A. N. Talbot (Chairman), Bremner, Brunner, Burton, Churchill, Cushing, Gennett (for Hunt), LaBach, Larsson, Ray, Reichmann, and Stimson.

Letters stating their inability to attend the meeting were received from Messrs. Dawley, Hale, Kittredge, and Willoughby, and Messrs. Baldwin and Safford who were also unable to attend the meeting, had presented their views on the proposed discussion in advance.

The Chairman presented a statement of progress in the reduction and preparation of data of tests on railroad track and an outline of future work. After a general discussion of this statement, the members of the Committee, on motion, duly seconded, adopted the plans presented by the Chairman.

Special Committee on General Form of Contract Standard Clauses

January 19th, 1922.—The first meeting of the Committee was called to order at 11 A. M., at the Headquarters of the Society. Present, George H. Pegram, Henry H. Quimby, and J. S. Langthorn (Secretary).

Mr. Langthorn was elected Temporary Chairman.

The $500 budget for 1922 was discussed, and it was agreed that the limited amount required that the work of the Committee be done mainly by correspondence and with meetings to be held as far as possible at the time of the annual meetings of the Society.

The minutes of the Washington, D. C., Conference, held December 15th, and 16th, 1922, in the Department of Commerce Building, were discussed. It was announced that a Sub-Committee of the Washington Conference had been appointed to prepare for the next meeting of the Conference in Washington, a tentative document for further consideration.

It was agreed that the Committee's objects would be best achieved by co-operating with the National Conference at Washington, and thus attain joint action of all the elements of the construction industry.

The "Standard Form of Agreement between Owner and Contractor", adopted by the Texas Section of the Society on October 28th, 1921, and sent to each member of the Committee by J. H. Brillhart, M. Am. Soc. C. E., was discussed, particular attention being given to the arbitration clause.

Certain suggestions of the Committee on Engineering Contracts of the Engineering Association of Nashville, Tenn., adopted by that Association, were forwarded by Hunter McDonald, Past-President, Am. Soc. C. E., presented to the Committee, and discussed.

Mr. Quimby presented several contracts of the City of Philadelphia and called attention to the provision for a time charge which acts as an automatic bonus and penalty scheme. He stated that it has been used satisfactorily for eight years.

On motion duly seconded, the meeting was adjourned subject to the call of the Chairman.

ITEMS OF INTEREST

This Society is not responsible for any statement made or opinion expressed in its publications.

The Committee on Publications will be glad to receive communications of general interest to the Society, and will consider them for publication in *Proceedings* in "Items of Interest". This is intended to cover letters or suggestions from our membership concerning matters which are not of a technical character. Such communications, however, must not be controversial or commercial.

Report of Volunteer Committee on Employment, of the Federated American Engineering Societies

The Volunteer Committee on Employment begs to submit the following report of its activities.

The latest advices show that, besides the New York City Committee, Volunteer Committees are operating in the following centers: Baltimore, Md., Birmingham, Ala., Boston, Mass., Bridgeport, Conn., Buffalo, N. Y., Chicago, Ill., Cleveland, Ohio, New Haven, Conn., Columbus, Ohio, Jersey City, N. J., Milwaukee, Wis., Newark, N. J., New Orleans, La., and St. Louis, Mo.

Reports are also being made to establish committees in: Detroit, Mich., Los Angeles, Cal., Philadelphia, Pa., Utica, N. Y., and Washington, D. C.

Reports on results achieved by committees outside of New York City are not available, but it appears that most of the volunteer activity centers in New York City, the other branches being still in the formative stage, or, at least, have not gotten fully under way.

The results of the work in New York City have been encouraging. Recently, calls have been made by committee members in lines of business in which the member himself is interested. This division of calls is felt to be a great improvement over the former system of miscellaneous calls by geographical location.

In general, a distinct improvement in business confidence and in the number of jobs available has been found. This is shown in Table 1, which reflects the continually increasing efforts of the Committee.

TABLE 1.

	Calls.	Bureau unknown.	Jobs.	Prospects.
Nov. 21st to Dec. 31st, 1921....................	312	112	9	19
Jan.1st to Mar.10th,1922.	1 496	597	96	116

These noteworthy results, nearly 1 500 calls made since the first of the year, 96 jobs uncovered, and 116 prospects, have been due to an increase in

the membership of the Committee, a more active directional policy, and a general increase in morale. The number of committee men has increased as follows: 8 on January 3d, 1922; 9 on February 1st, 1922; 21 on March 1st, 1922; and 23 on March 10th, 1922. Of the 23 members on March 10th, 7 have been on executive work, the remainder being "Field Men".

The work of the Employment Bureau as a whole, which includes the efforts of the Volunteer Committee, during the first two months of 1922, compares favorably with the same period in 1921. Table 2 shows this in detail.

TABLE 2.

	1921.			1922.			Net change for two-month period.
	January.	February.	Total.	January.	February.	Total.	
New men registered..	195	174	369	142	138	280	—89
Positions received....	120	111	231	186	233	419	188
Men placed............	91	107	198	131	114	245	47

With 89 fewer new men registered, 188 more positions available, and 47 more men placed, the improvement as compared with 1921, for the same period, is unquestioned.

Conference on Business Training of Engineers and Engineering Training for Students of Business

The United States Commissioner of Education is calling a Second Public Conference on Commercial Engineering on behalf of a Committee on Commercial Engineering appointed by him to investigate the business training of engineers and engineering training for students of business.

The conference will be held May 1st and 2d, 1922, at the Carnegie Institute of Technology in Pittsburgh, Pa. President Arthur Hamerschlag, of the Institute, is a member of the Committee which is composed of prominent deans of schools of engineering, of commerce in the larger universities, and of engineers and business men who are Nationally known for their interest in the reduction of the costs of production, distribution, transportation, etc., through better training in schools and colleges of the personnel of industry and commerce.

The Conference will be open to the public. Invitations to appoint delegates to the Pittsburgh Conference, however, will be sent by the Commissioner of Education to commercial and trade organizations, engineering and scientific societies, educational institutions, and other groups, as well as to prominent individuals.

Owing to the timeliness of the subject, the Conference in Pittsburgh will even have greater National significance than the First Public Conference on this question, which was held in Washington, D. C., two and one-half years ago under the direction of this Committee on Commercial Engineering of which Dr. Glen Levin Swiggett, of the Bureau of Education, is Chairman.

The four major topics of the conference, it is stated, will be presented and discussed at general and round table sessions by business men, educators, and engineers, contributing to the construction of a co-operative program between education and business for the better co-ordination of all productive and distributive processes in trade and commerce. It is planned to have the Second Conference even more constructive than the first, since which time the curricula of 29 of the 119 engineering colleges reporting to the Bureau of Education have been favorably modified to include one or more of the four Committee recommendations. Outstanding topics at the Pittsburgh Conference will deal with the new problems that have recently arisen in modern industries, the solution of which demands a more scientific approach to include job analyses and personnel specifications, and a translation of these into a new and teachable content for use in engineering and commercial schools; with the training of the engineer for a better understanding of problems relating to community development; and with training of the engineer for management of overseas engineering projects.

ACTIVITIES OF LOCAL SECTIONS*

Meeting of Colorado Section

A regular meeting of the Colorado Section was held at the Metropole Hotel, Denver, Colo., on February 13th, 1922; President A. N. Miller in the chair; Thomas H. Olds, Secretary; and present, also, 11 members and 1 guest.

President Miller announced the resignation of Mr. Walter L. Drager as Secretary-Treasurer, and the appointment of Mr. Thomas H. Olds to complete the unexpired term.

Mr. L. E. Thompson, President and General Manager of the Thompson Manufacturing Company, gave an interesting lecture on "Metal Flumes", emphasizing particularly the life of flumes constructed of galvanized iron, pure iron, and zinc. He discussed briefly the history of flumes and the search for a metal that would successfully resist corrosion, presenting the results of a number of tests to determine the loss of weight by corrosion of various metals used in the manufacture of flumes.

The minutes of the two previous meetings of the Section were read and approved.

The Secretary presented a letter from the Colorado Engineering Council in regard to the adoption of the metric system. A motion to advise the Engineering Council that the Section favors the adoption of the metric system was defeated, and no further action was taken.

Mr. Arthur Ridgway was elected as delegate and Mr. H. S. Crocker as alternate delegate to the Colorado Engineering Council.

A blank resolution proposed by the Colorado Engineering Council requesting the Mayor of Denver to arrange for the purchase of a block on Bannock Street, in order to prevent the erection of a commercial building and to provide a site for a county and municipal building, was read, and on motion, duly seconded, was adopted.

Mr. H. S. Crocker spoke briefly on the status of the plans for the new or reconstructed Sixteenth Street Viaduct, and the manufacture of high-pressure concrete conduits was discussed briefly by Mr. W. B. Freeman.

Meetings of Duluth Section

A regular meeting of the Duluth Section was called to order at 12:15 P. M., February 20th, 1922; President John L. Pickles in the chair; W. G. Zimmermann, Secretary; and present, also, 21 members.

The minutes of the meeting of January 16th, 1922, were read and approved.

Mr. E. K. Coe presented a report of the Committee on City Planning in Duluth, and stated that the recommendations adopted by the Committee for the proposed City Planning Ordinance had been accepted by the Mayor and incorporated in the revised ordinance. On motion, duly seconded, the revised ordinance was endorsed by the meeting, and the Secretary was instructed to notify the Mayor to that effect.

A letter was presented from Mr. Richard L. Humphrey in regard to the vote on the proposed amendments to the Constitution of the Society to be

* For list of Local Sections, Officers, etc., see p. 340.

canvassed on March 1st, 1922, and the subject was discussed in detail by Mr. O. H. Dickerson who also made a report on the Annual Meeting of the Society in New York City.

Mr. W. E. Hawley reported on the subject of the Society becoming a member of the Federated American Engineering Societies, and on motion, duly seconded, the following resolution was adopted:

"*Whereas:* The movement to strengthen the position of the American Professional Engineer by securing unity of effort between the various branches of engineering has brought forth the Federated American Engineering Societies;

"*Whereas:* This organization has been in useful and successful operation in its pursuit of the work for which it was organized over a year ago;

"*Whereas:* Individual members of the American Society of Civil Engineers have taken an active interest in assisting the new organization, thereby exerting a large influence on its welfare in the work of raising the engineer to a higher position in the national affairs;

"*Whereas:* The American Society of Civil Engineers has not as yet through its official acts become a member society of the Federated American Engineering Societies;

"*Whereas:* The efforts of the Federated American Engineering Societies redounds to the benefit of the individual members of the American Society of Civil Engineers and yet the American Society of Civil Engineers does not financially support the Federated American Engineering Societies;

"*Be it Resolved:* That the Duluth Section of the American Society of Civil Engineers hereby express its belief that the parent society should assume its share of the financial support of the Federated American Engineering Societies by officially joining it as soon as the financial affairs of the American Society of Civil Engineers can be adjusted to meet the new responsibility;

"*Further:* That those members of the American Society of Civil Engineers who have already aided the Federated American Engineering Societies be commended and the membership at large be asked to lend every possible aid to the new federation to increase its services to the public and its value to the engineer;

"*Further:* That a copy of these resolutions be sent to the Board of Direction of the American Society of Civil Engineers and that they be asked to send out to the membership of the Society a letter-ballot providing therein for a vote of approval or disapproval of the American Society of Civil Engineers by appropriate action joining the Federated American Engineering Societies.

"*Further:* That a copy of these resolutions be sent to the various Sections and to the Executive Secretary of the Federated American Engineering Societies."

Meeting of March 20th, 1922

A regular meeting of the Section was held on March 20th, 1922, at 12:15 P. M.; President John L. Pickles in the chair; W. E. Hawley, Acting Secretary; and present, also, 20 members and 1 guest.

The minutes of the meeting of February 20th, 1922, were read and approved.

A letter from the Acting Secretary of the Society was presented, relative to his visit to the Duluth Section next fall. He also outlined the plans for the Spring Meeting at Dayton, Ohio, the summer Convention at Portsmouth, N. H., and the Fall Meeting on the Pacific Coast.

Mr. F. Hutchinson, as Chairman of the Committee, reported on the circular letter from the Acting Secretary relative to the publication in *Proceedings* of sections of the Catalog of the Engineering Societies Library. After discussion by Messrs. Hoyt, Stack, Coe, Swart, and Taylor, on motion, duly seconded, the following resolution was adopted:

"*Resolved:* That the Duluth Section cordially approves the publication in the January *Proceedings*, of a catalog of literature upon Highway Engineering. It is the opinion of the Duluth Section that the best interests of the Society will be served by deferring the publication of the balance of the Engineering Societies Library Catalog until such time as it can be issued in loose leaf or pamphlet form.

"If it be finally thought advisable to publish further portions of the Catalog, we suggest that such portions be issued as separate pamphlets."

A paper on "Standardization" was presented by Mr. W. A. Clark, in which he outlined the past history and present progress of the movement and its advantages and defects, and the subject was discussed by Messrs. Hoyt, Hawley, Stack, Taylor, and Woodbury.

Organization and Meetings of the Dayton Section

The decision to organize a Dayton Section was made at a meeting at the Engineers Club, Dayton, Ohio, on January 23d, 1922. A Constitution was adopted and forwarded to the Board of Direction for approval. On receipt of its approval, a meeting was held at the Engineers Club, on February 27th, 1922, at which the Dayton Section was formally organized and the following officers were elected: President, Charles H. Paul; First Vice-President, J. H. Kimball; Second Vice-President, O. N. Floyd; and Secretary-Treasurer, K. C. Grant.

At this meeting the report of the Committee of Local Arrangements for the Spring Meeting of the Society to be held in Dayton, was approved and the program adopted to supplement the technical program was forwarded to the Secretary of the Society.

On February 20th, 1922, the members of the Section entertained the Acting Secretary at a luncheon at the Engineers Club. The program for the Spring Meeting of the Society was outlined, and there was considerable discussion as to the entertainments, excursions, etc.

On February 29th, 1922, a meeting of the Section was held at the Engineers Club, at which the detailed program of the Spring Meeting was discussed and approved.

New York Section Participates in Joint Meeting on the Port of New York

The Third Joint Meeting of the Metropolitan Sections of the Founder Societies was held in the Auditorium of the Engineering Societies Building on March 15th, 1922; President Nelson P. Lewis, of the New York Section of the American Society of Civil Engineers, in the chair; J. P. J. Williams, Secretary; and present, also, about 850 members and guests.

The subject of the evening, "The Development of the Port of New York", was presented by Messrs. E. H. Outerbridge, Chairman of the Port of New

York Authority, and B. F. Cresson, Jr., Chief Engineer. Owing to urgent business engagements, it was impossible for Messrs. E. B. Temple, Assistant Chief Engineer of the Pennsylvania Railroad, and J. J. Mantell, General Manager of the Erie Railroad, to be present and speak for the railroads. Mr. Morris R. Sherrerd, Consulting Engineer, of Newark, N. J., discussed the subject as it affected the New Jersey side of the Port, and Messrs. John Francis and P. V. Stephens made brief remarks from the floor.

In addition to the general outline of the plans of the Port Authority and the powers vested in it, Mr. Cresson explained in detail the extensive organization proposed by the Port Authority at the time of the threatened strike of the railroad workers, which, with studies of the needs of the City in order to provide daily food requirements, is available if any such emergency should arise.

A moving picture film of the Port was shown, in which the complete transportation history of a common article of food through the city to its destination was represented.

Sub-Section Conference on Details of Design

At 5:15 p. m., preceding the Joint Meeting on March 15th, 1922, the first of a series of three conferences which had been decided on as the result of the questionnaire sent to members of the Section, was held to consider the subject, "The Importance of the Design of Details, as Evidenced by Recent Theater Failures." An attendance of about 65 showed the interest of the membership, which was further demonstrated by the active participation of many of those present in the discussion. Under the chairmanship of Mr. James H. Edwards, Assistant Chief Engineer of the American Bridge Company, the important details in the design of the Knickerbocker Theater, Washington, D. C., and many other examples of questionable structural detailing, were freely illustrated. The question of responsibility for such failures was raised, and suggestions that more definite laws placing responsibility should be passed, were made.

On motion, duly seconded, and carried, the meeting approved the plan proposing two other conferences on related topics, to be held on the afternoons preceding the regular meetings in April and May, and elected Mr. Edwards to act as Chairman at such Sub-Section meetings.

Meeting of Pittsburgh Section

A meeting of the Pittsburgh Section was held at the Hotel Chatham, on February 24th, 1922; Vice-President J. L. De Vou in the chair; Nathan Schein, Secretary; and present, also, 34 members.

J. H. Edwards, M. Am. Soc. C. E., and Elbert M. Chandler, Acting Secretary of the Society, were present as guests.

The minutes of the previous meeting of the Section were read and approved.

The Secretary reported that the Section had received the sum of $169 from the Society as its share of the distribution of the funds to Local Sections.

The Secretary presented the report of the meeting of the Executive and Activities Committee of the Section, which was held on February 15th, 1922.

The following names of members of the Section were submitted to the Student Chapter of the University of Pittsburgh as speakers at its meetings: Messrs. E. J. Dilworth, J. L. De Vou, Richard Khuen, A. W. Thompson, J. N. Chester, George S. Davison, Morris Knowles, E. K. Morse, and C. L. Wooldridge.

On motion, duly seconded, the Secretary was instructed to prepare a circular letter to resident members of the Society in this District, informing them of the activities of the Section and urging them to become members of the same.

It was announced that the Executive Committee had endorsed the action of the Pittsburgh Associated Engineers Society in inviting the Executive Board of the American Engineering Council to Pittsburgh for its May meeting, and on motion, duly seconded, the Secretary was instructed to pay the Section's portion of expense of the meeting of the Federated American Engineering Societies in Pittsburgh.

The Secretary announced that the return of the letter-ballot on the question of the Society joining the Federated American Engineering Societies stood 72 for and 8 against the proposition.

On motion, duly seconded, it was decided to postpone the discussion on the advisability of presenting engineering papers before the Section until a later meeting.

An address on the motives of members in presenting papers at meetings was made by Mr. Edwards. He was followed by Mr. Chandler who discussed the meeting of the Society at Dayton, Ohio, and the work of the Society.

On motion, duly seconded, a vote of thanks was extended to Mr. Edwards and Mr. Chandler.

On motion, duly seconded, the Section commended the action of the Board of Direction in sending the Acting Secretary to visit the Local Sections.

On motion, duly seconded, the Chairman was instructed to appoint a committee to canvass the Section with reference to those who wish to attend the Spring meeting of the Society in Dayton, Ohio, and Vice-President De Vou subsequently appointed Messrs. E. D. Davis, Maurice Scharff, and L. J. Riegler as such committee.

After the adjournment of the meeting, an informal reception was tendered Acting Secretary Chandler of the Society.

Meeting of Portland Section

A meeting of the Portland Section was called to order at the University Club at 8 P. M.; President F. M. Randlett in the chair; C. P. Keyser, Secretary; and present, also, 29 members.

The minutes of the meeting of February 17th, 1922, were read and approved.

Mr. G. C. Mason, Chairman of the Committee on Redraft of the Constitution of the Section, presented a draft of a constitution and moved its

adoption, which motion was seconded. The Secretary read the report of the Committee, and after considerable discussion a motion to adopt the revised Constitution section by section was lost. The original motion was then adopted, and the Committee was discharged with the thanks of the Section.

Mr. R. G. Dieck, Chairman of the Committee on Prizes for papers by engineering students at the Oregon Agricultural College, presented a report of that Committee. After discussion and the adoption of two amendments, which were accepted by the Chairman of the Committee, the report was, on motion, duly seconded, accepted.

On motion, duly seconded, the Secretary was instructed to reply to a letter of Acting Secretary Chandler bearing on the question of allocating dues, stating that all members of all grades in good standing in the Society and resident in Oregon were in good standing with the Portland Section on January 1st, 1922.

On motion, duly seconded, it was decided to accept the invitation of Mr. E. B. Thomson to join the members of the Portland Chapter of American Military Engineers in a visit to the Oregon Agricultural College on April 1st, 1922.

The meeting was then turned over to Mr. C. N. Bennett who conducted a discussion of the question now before the Section on "Shall the American Society of Civil Engineers join the Federated American Engineering Societies". The discussion was opened by Mr. Bennett who reviewed the history of the organization. He was followed by Messrs. Berni, McKesson, White, Schubert, and Brown. On motion, duly seconded, after lengthy discussion, the following resolution was adopted:

"*Resolved:* That it is the opinion of the Portland Section, Am. Soc. C. E., that no action should be taken at this time toward a reconsideration of the decision as expressed by letter ballot of Nov. 8th, 1920, that the American Society of Civil Engineers should not become affiliated with the Federated American Engineering Societies".

Meetings of the St. Louis Section

A regular meeting of the St. Louis Section was called to order at the American Annex on January 23d, 1922; President E. B. Fay in the chair; William C. E. Becker, Secretary; and present, also, 17 members and 1 guest.

The minutes of the previous meeting were read and approved.

A letter from the St. Louis Citizens' New Constitution Association, asking for co-operation in formulating suggestions to the Constitutional Convention, was presented, and, on motion, duly seconded, Mr. W. W. Horner was delegated to present any suggestions to the Association from members of the Section.

On motion, duly seconded, a resolution on the death of Hiram Phillips, M. Am. Soc. C. E., prepared by Messrs. E. E. Wall, J. T. Garrett, and S. Bent Russell, was read and adopted. A memoir of the late Mr. Phillips prepared by the same Committee, was also read and approved and, on motion, duly seconded, ordered sent to the Acting Secretary of the Society for publication in *Proceedings.**

* See p. 1039 of Papers and Discussions.

Messrs. Baxter L. Brown and E. E. Wall presented brief accounts of the Annual Meeting of the Society.

On motion, duly seconded, the Secretary was instructed to send a special letter to those members of the Society in St. Louis not members of the Section inviting them to join.

The subject, "What Should Be Done by Engineers to Prevent the Practice of Competing Bidders Making Unfair Use of Each Other's Designs when Complete Plans Are not Furnished by the Purchaser", was presented and discussed by Messrs. J. T. Garrett, F. D. Hughes, Baxter L. Brown, S. Bent Russell, and R. P. Garrett. The discussion brought out the fact that the practice was not so popular at present on account of the expense of preparing plans, and that the best that engineers could do to prevent it was to give the practice publicity and censure it.

Meeting of February 27th, 1922.

A regular meeting of the St. Louis Section was called to order at the American Annex on February 27th, 1922; President E. B. Fay in the chair; William C. E. Becker, Secretary; and present, also, 17 members and 1 guest.

The minutes of the previous meeting were read and approved.

Letters were presented from the Acting Secretary of the Society relative to the Spring Meeting to be held at Dayton, Ohio, on April 5th and 6th, 1922, and to the allocation of a portion of the dues of its members to the Section.

The Secretary presented a letter from the Engineers Club of Kansas City relative to an Engineering Congress to be devoted to a symposium on the "Petroleum Industry", to be held at Kansas City, Mo., on March 6th and 7th, 1922.

Mr. E. E. Wall announced that $21 of a fund raised by the Section was available, and on motion, duly seconded, it was voted to offer this sum as a subscription from the Section to the James Buchanan Eads Fund.

Discussion on the subject "To What Extent Can the Development of St. Louis and East St. Louis Be Promoted Through the Operation of Metropolitan Districts", was opened by Mr. H. Wright, Architect for the City Plan Commission. After a brief discussion by several members present, it was decided, on motion, duly seconded, to continue the discussion at the next meeting of the Section.

Meeting of Seattle Section

The regular meeting of the Seattle Section was held at the Engineers' Club on February 27th, 1922; President F. F. Sinks in the chair; Frank H. Fowler, Secretary; and present, also, 21 members.

The minutes of the meeting of January 30th, 1922, were read and approved.

On motion, duly seconded, the Secretary was instructed to postpone action regarding the binding of the volumes of *Proceedings,* donated to the Section by the Society, until the next meeting.

The address of the evening was delivered by Mr. Ralph Stacey, who spoke on the subject of "Intelligent Patriotism".

Announcement was made of the appointment by the Chairman of the members of the Advisory Committee, Membership Committee, Legislative Committee, Parent Relationship Committee, Entertainment Committee, Program Committee, and Intersectional Society Committee.

On motion, duly seconded, the Secretary was authorized to consult with the Spokane Section on the matter of territorial limits embraced by the Spokane and Seattle Sections.

The question of members who reside within the State of Washington and adjacent to the Columbia River affiliating themselves with the Portland Section was discussed, and, on motion, duly seconded, the Secretary was instructed to take up the matter with members of the Society in Vancouver, Wash.

EMPLOYMENT SERVICE OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

An Engineering Societies Service Bureau was established December 1st, 1918, as an activity of Engineering Council, managed by a board made up of the Secretaries of the four Founder Societies, funds for its maintenance being provided by these Societies. On January 1st, 1921, this Bureau was taken over by The Federated American Engineering Societies and is now known as the Employment Service of that organization. It is co-operating with engineering organizations in all parts of the country and is desirous of increasing such co-operation by working with local engineering associations and clubs. Members of the American Society of Civil Engineers who desire to register should apply for further information, registration forms, etc., to Walter V. Brown, Manager, Engineering Societies Building, 29 West 39th Street, New York City. In order to be included in the list published in *Proceedings,* copy must be received on or before the first Wednesday of each month. All communications should be addressed to Mr. Brown.

EMPLOYMENT BULLETIN

POSITIONS AVAILABLE

YOUNG ENGINEERS with some sales, architectural, or building experience, to learn business, with view to sales work. Application by letter only. Location, New York City. V–448.

GRADUATE CIVIL ENGINEER with marine construction experience, along wharf and pier lines, for research and office work. Must be man of appearance, capable of meeting people. Knowledge of French, German, Scandinavian, or Dutch desirable. Must also be familiar with the destruction of piling and piers by the *teredo limnoria,* etc. Application by letter. Location, New York City. V–696.

MEN AVAILABLE

PATENT ENGINEER, M. E. and E. E., age 42, married. Registered Attorney of twenty years' standing. Specialist in mechanical movements, desires connection on part time with a corporation to take charge of organization of Patent Department. Location, Metropolitan District. CE–324.

GRADUATE ENGINEER. Three years' experience in manufacturing and selling steel products. Position anywhere in United States. CE–325.

CIVIL ENGINEER AND CONSTRUCTION SUPERINTENDENT, age 35. Twelve years' field experience in construction of industrial buildings, construction and repair of open-hearth and heating furnaces, and plant maintenance and repairs in steel plant. Last employed as Resident Engineer for prominent architect and engineer. Has successfully handled large force of men. CE–326.

CIVIL ENGINEER, Assoc. M. Am. Soc. C. E., age 40, married. Seventeen years' experience in miscellaneous engineering and construction work, including designs, heavy earthwork, railroad yards and buildings, etc. Extensive steam and electric railway valuation and maintenance. Now employed in executive position with large utility property. Desires change. Will consider position with railway, industry or contractor. Personal interview solicited. CE–327.

CIVIL-MECHANICAL SUPERVISING ENGINEER, Assoc. M. Am. Soc. C. E., age 35. Well varied experience in power, hydraulic, and industrial work, both engineering and construction. Record of responsible and executive connections with well-known organizations; thorough business training. Experience throughout the country; now in Chicago District. CE–328.

FIELD ENGINEER, Assoc. M. Am. Soc. C. E., C. E. Degree 1913, age 38. Eight years' experience on location and construction, covering concrete shipbuilding, hydro-electric power development, irrigation, railroad, and highway work. CE–329.

CIVIL ENGINEER of many years' practical experience, thoroughly acquainted with Australia, desires to take on agencies for American firms. Now located in Sydney. CE–330.

GRADUATE CIVIL ENGINEER AND CONSTRUCTION SUPERINTENDENT, Assoc. M. Am. Soc. C. E., age 34, degree 1908. Twelve years' experience on roads, bridges, surveys, sewers, water-works, and concrete industrial buildings. Experience includes design, inspection, and superintendence. Two years in charge of war work for Construction Division, U. S. A. Available at once. Location immaterial. CE–331.

CIVIL AND MECHANICAL ENGINEER, Assoc. M. Am. Soc. C. E., married, experienced in water supply, filtration, pumping engine design, pumping and power plant design, hydraulic work in general, and engineering sales work, is open for engagement. Twelve years' experience, the past two years in the Orient. Prefers to remain in the United States, but will consider a foreign proposition. Minimum salary, $5 000. CE–332.

ANNOUNCEMENTS

The Reading Room of the Society is open from 9 A. M. to 6 P. M., and from 7 P. M. to 10 P. M., every day, except Sundays, New Year's Day, Washington's Birthday, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day; during July and August, it is closed at 6 P. M.

PROGRAM FOR MONTHLY SOCIETY MEETINGS

The Publication Committee announces the following program covering the monthly meetings up to the summer recess. In each case, the meetings will be held on the Fifth Floor of the Engineering Societies Building, 33 West 39th St., New York City, at 8 P. M., on the days noted.

May 3d, 1922.—A regular monthly business meeting will be held, at which a paper by Arthur T. Safford, M. Am. Soc. C. E., and Edward Pierce Hamilton, Esq., entitled "The American Mixed-Flow Turbine and Its Setting", will be presented by Mr. Safford for discussion.

This paper is printed in this number of *Proceedings*.

June 7th, 1922.—Informal discussion on "Tentative Specifications for Steel Railway Bridges", submitted as a Progress Report of the Special Committee on Specifications for Bridge Design and Construction, and published in the December, 1921, *Proceedings*.

Discussion on this Report is printed in this number of *Proceedings*.

ANNUAL CONVENTION

The Fifty-second Annual Convention of the Society will be held at the Hotel Wentworth, Portsmouth, N. H., on June 21st and 22d, 1922.

BADGES FOR JUNIORS AND STUDENTS

After May 1st, 1922, badges will be issued to Juniors and Students. Juniors and Secretaries of Student Chapters will be notified by letter of style and price.

SCHOLARSHIP IN CIVIL ENGINEERING AT COLUMBIA UNIVERSITY

The governing bodies of Columbia University have placed at the disposal of the Society, a scholarship in Civil Engineering in the Schools of Mines, Engineering and Chemistry of Columbia University, beginning with the academic year 1922-23 and continuing until further notice. The scholarship pays $350 toward the annual tuition fees, which vary from $340 to $360, according to the details of the course selected. Re-appointment of the student to the scholarship for the completion of his course is conditioned upon the maintenance of a good standing in his work.

To be eligible for the scholarship, the candidate recommended will have to meet the regular admission requirements, in regard to which full information will be sent without charge upon application to the Secretary of the University or to the Secretary of the Society.

In a letter addressed to the Secretary of the Society, an applicant for this scholarship should set forth his qualifications (age, place of birth, education, statement of any other activities, such as athletics or working way through

college, references, and photograph). A committee composed of Messrs. Robert Ridgway, C. W. Hudson, and J. P. H. Perry will consider the applications and will notify the authorities of Columbia University of their selection of a candidate. The last day for the filing of applications will be July 1st of each year.

The course at the Columbia Schools of Mines, Engineering and Chemistry is three years in length and is on a graduate basis. A candidate for admission must have had a general education, including considerable work in mathematics, physics, and chemistry. Three years of preparatory work in a good college or scientific school should be sufficient, if special attention has been given to the three preparatory subjects mentioned. A college graduate, with a Bachelor of Science degree in engineering, can generally qualify to advantage. The candidate is admitted on the basis of his previous collegiate record, and without undergoing special examinations. Other qualifications being equal, members of Student Chapters of the Society will be given preference.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that members will show a keen interest in this scholarship, which will insure the choice of a candidate of the highest qualifications.

LOCAL SECTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Section (Constitution Approved by Board, 1905).

Thomas H. Means, President; H. D. Dewell, Secretary-Treasurer, 503 Market Street, San Francisco, Cal.

Colorado Section (Constitution Approved by Board, 1909).

A. N. Miller, President; Thomas H. Olds, Secretary-Treasurer, First National Bank Building, Denver, Colo.

Atlanta Section (Constitution Approved by Board, 1912).

William C. Spiker, President; Frederick H. McDonald, Secretary-Treasurer, 1530 Healy Building, Atlanta, Ga.

Baltimore Section (Constitution Approved by Board, 1914).

Ezra B. Whitman, President; George S. Robertson, Sr., Secretary-Treasurer, 1628 Linden Avenue, Baltimore, Md.

Buffalo Section (Constitution Approved by Board, 1921).

Walter McCulloh, President; John H. Feigel, Secretary-Treasurer, 492 Minnesota Ave., Buffalo, N. Y.

Central Ohio Section (Constitution Approved by Board, 1921).

F. H. Eno, President; H. F. Schryver, Secretary, 405 New York Central Building, Columbus, Ohio.

Cincinnati Section (Constitution Approved by Board, 1920).

Edgar Dow Gilman, President; Alphonse M. Westenhoff, Secretary, 709 Gwynne Bldg., Cincinnati, Ohio.

Cleveland Section (Constitution Approved by Board, 1915).

A. V. Ruggles, President; George H. Tinker, Secretary-Treasurer, 516 Columbia Building, Cleveland, Ohio.

Connecticut Section (Constitution Approved by Board, 1919).

William J. Backes, President; Clarence M. Blair, Secretary-Treasurer, 785 Edgewood Avenue, New Haven, Conn.

Dayton Section (Constitution Approved by Board, 1922).

Charles H. Paul, President; K. C. Grant, Secretary-Treasurer, Winters Bank Building, Dayton, Ohio.

Detroit Section (Constitution Approved by Board, 1916).

H. H. Esselstyn, President; Alex. Linn Trout, Secretary-Treasurer, 110 North Ingalls Street, Ann Arbor, Mich.

District of Columbia Section (Constitution Approved by Board, 1916).

Gratz B. Strickler, President; James H. Van Wagenen, Secretary-Treasurer, 2001 Sixteenth Street, N. W., Washington, D. C.

Duluth Section (Constitution Approved by Board, 1917).

John L. Pickles, President; Walter G. Zimmermann, Secretary, 203 Wolvin Building, Duluth, Minn.

Illinois Section (Constitution Approved by Board, 1916).

A. J. Hammond, President; W. D. Gerber, Secretary-Treasurer, 913 Chamber of Commerce, Chicago, Ill.

Iowa Section (Constitution Approved by Board, 1920).

J. H. Dunlap, President; R. W. Crum, Secretary, Care, Iowa State Highway Commission, Ames, Iowa.

Kansas City (Mo.) Section (Constitution Approved by Board, 1921).

John V. Hanna, President; Henry C. Tammen, Secretary-Treasurer, 1012 Baltimore Avenue, Kansas City, Mo.

Kansas Section (Constitution Approved by Board, 1920).

L. E. Conrad, President; Frank S. Altman, Secretary-Treasurer, 1114 Garfield Avenue, Topeka, Kans.

Los Angeles Section (Constitution Approved by Board, 1913).

Ralph J. Reed, President; Floyd G. Dessery, Secretary, 618 Central Building, Los Angeles, Cal.

Louisiana Section (Constitution Approved by Board, 1914).

Ole K. Olsen, President; F. A. Muth, Secretary, 224 Custom House Building, New Orleans, La.

Nashville Section (Constitution Approved by Board, 1921).

B. H. Klyce, President; L. C. Anderson, Secretary-Treasurer, Bridge Building, Nashville, Tenn.

Nebraska Section (Constitution Approved by Board, 1917).

William Grant, President; Homer V. Knouse, Secretary-Treasurer, 200 City Hall, Omaha, Nebr.

New York Section (Constitution Approved by Board, 1920).

Nelson P. Lewis, President; J. P. J. Williams, Secretary, 33 West 39th Street, New York City.

Northeastern Section (Constitution Approved by Board, 1921).

Frank B. Sanborn, Chairman; Charles W. Banks, Secretary, Wentworth Institute, Boston, Mass.

Northwestern Section (Constitution Approved by Board, 1914).

Charles L. Pillsbury, President; Paul C. Gauger, Secretary, 945 Osceola Avenue, St. Paul, Minn.

Oklahoma Section (Constitution Approved by Board, 1920).

Max L. Cunningham, President; R. E. Brownell, Secretary-Treasurer, 402 First National Bank Building, Oklahoma, Okla.

Philadelphia Section (Constitution Approved by Board, 1913).

Benjamin Franklin, President; S. C. Hollister, Secretary, 1200 Land Title Building, Philadelphia, Pa.

Pittsburgh Section (Constitution Approved by Board, 1918).

J. N. Chester, President; Nathan Schein, Secretary-Treasurer, 1510 Carson Street, Pittsburgh, Pa.

Portland (Ore.) Section (Constitution Approved by Board, 1913).

F. M. Randlett, President; C. P. Keyser, Secretary, 318 City Hall, Portland, Ore.

Providence (R. I.) Section (Constitution Approved by Board, 1920).

Sydney Wilmot, Chairman; Robert L. Bowen, Secretary-Treasurer, 26 Sycamore Street, Providence, R. I.

St. Louis Section (Constitution Approved by Board, 1914).

E. B. Fay, President; William C. E. Becker, Secretary-Treasurer, 426 City Hall, St. Louis, Mo.

San Diego Section (Constitution Approved by Board, 1915).

F. J. Grumm, President; J. Y. Jewett, Secretary-Treasurer, Administration Building, Balboa Park, San Diego, Cal.

Seattle Section (Constitution Approved by Board, 1913).

F. F. Sinks, President; Frank H. Fowler, Secretary-Treasurer, 1319 L. C. Smith Building, Seattle, Wash.

Spokane Section (Constitution Approved by Board, 1914).

C. A. Burnette, President; Charles E. Davis, Secretary-Treasurer, 401 City Hall, Spokane, Wash.

Texas Section (Constitution Approved by Board, 1913).

E. B. Cushing, President; E. N. Noyes, Secretary, 1107 Dallas County Bank Building, Dallas, Tex.

Utah Section (Constitution Approved by Board, 1916).

W. R. Armstrong, President; H. S. Kleinschmidt, Secretary-Treasurer, 222 Felt Building, Salt Lake City, Utah.

Virginia Section (Constitution Approved by Board, 1922).

J. C. Carpenter, President; James F. MacTier, Secretary-Treasurer, 1312 Maple Avenue, Roanoke, Va.

STUDENT CHAPTERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS*

Stanford University.

R. I. Hill, President; John H. Colton, Corresponding Secretary, Box 121, Stanford, Cal.

* By a recent ruling of the Board of Direction, the minimum membership of a Student Chapter has been fixed at 12 instead of 20.

Alabama Polytechnic Institute.

R. O. Davis, President; A. R. Harvey, Jr., Secretary-Treasurer, Box 661, Auburn, Ala.

Braune Civil Engineering Society (University of Cincinnati).

John W. Guilday, President; C. A. Harrell, Secretary of Section 10; R. Blickensderfer, Secretary of Section 20; University of Cincinnati, Cincinnati, Ohio.

Bucknell University.

Ralph F. Hartz, President; Donald A. Davis, Secretary, Bucknell University, Lewisburg, Pa.

California Institute of Technology.

W. M. Taggart, President; Douglas A. Stromsoe, Secretary, California Institute of Technology, Pasadena, Cal.

Carnegie Institute of Technology.

H. T. Ward, President; J. K. Elliott, Secretary, Carnegie Institute of Technology, Pittsburgh, Pa.

Clemson Agricultural and Mechanical College of South Carolina.

J. H. Baumann, President; W. J. Stribling, Secretary, Clemson Agricultural and Mechanical College of South Carolina, Clemson College, S. C.

Cornell University.

James Hannigan, President; Albert Lucas, Secretary-Treasurer, Lincoln Hall, Cornell University, Ithaca, N. Y.

Drexel Institute.

C. V. Nishwitz, Chairman; Raymond Radbill, Secretary, Drexel Institute, Philadelphia, Pa.

Georgia School of Technology.

F. H. Harrison, President; C. M. Kennedy, Jr., Secretary, 91 West North Avenue, Atlanta, Ga.

Iowa State College.

Raymond L. Whannel, President; C. La Verne Day, Secretary, Iowa State College, Ames, Iowa.

Johns Hopkins University.

W. A. Randall, President; I. M. Zeskind, Secretary, Johns Hopkins University, Baltimore, Md.

Lafayette College.

Douglas M. Brown, President; Ivan C. Blickenstaff, Secretary, Lafayette College, Easton, Pa.

Lehigh University

John N. Marshall, President; George R. Swinton, Lehigh University, Bethlehem, Pa.

Massachusetts Institute of Technology

D. H. McCreery, President; T. S. Wray, Secretary, Massachusetts Institute of Technology, Cambridge, Mass.

Montana State College.

Merrill J. Alquist, President; Emmett Moore, Secretary, 921 South Third Avenue, Bozeman, Mont.

New York University.

George H. Martin, President; Abram J. Jacobs, Secretary, 302 Gould Hall, New York University, New York City.

Norwich University.

Allen J. Hamilton, Secretary, Norwich University, Northfield, Vt.

Ohio State University.

O. W. Merrell, President; William M. Ruddicks, Secretary, 65 Thirteenth Avenue, Columbus, Ohio.

Oregon State Agricultural College.

Richard D. Slater, President; Wilbur H. Welch, Secretary, Oregon State Agricultural College, Corvallis, Ore.

Pennsylvania State College.

Arthur H. McFadden, President; William W. Seltzer, Secretary, Pennsylvania State College, State College, Pa.

Polytechnic Institute of Brooklyn.

W. C. Hanning, President; S. Lordi, Secretary, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Purdue University.

R. O. Edwards, President; W. C. Mason, Secretary-Treasurer, Purdue University, West Lafayette, Ind.

Rensselaer Polytechnic Institute.

William Minot Thomas, President; Earl D. Hopkins, Secretary, 147 Eighth Street, Troy, N. Y.

Rose Polytechnic Institute.

Robert Cash, President; F. Ray Martin, Secretary-Treasurer, Rose Polytechnic Institute, Terre Haute, Ind.

Rutgers College.

L. C. Kuhl, President; A. C. Ely, Secretary, 105 Winants Hall, Rutgers College, New Brunswick, N. J.

State University of Iowa.

James Fred Phillips, President; Louis E. Baggs, Secretary, State University of Iowa, Iowa City, Iowa.

Swarthmore College.

Frank Lemke, President; H. Chandlee Turner, Jr., Secretary, Swarthmore College, Swarthmore, Pa.

Syracuse University.

Arthur V. Dollard, Secretary, College of Applied Science, Syracuse University, Syracuse, N. Y.

University of California.

E. F. Sutherland, President; H. E. Hedger, Secretary, University of California, Berkeley, Cal.

University of Colorado.

Herbert Altvater, President; Charles Bowden, Secretary, 1229 University Avenue, Boulder, Colo.

University of Illinois.

A. L. R. Sanders, President; M. E. Jansson, Secretary, University of Illinois, Urbana, Ill.

University of Kansas.

W. W. Hoagland, President; Waldo G. Bowman, Secretary, 1106 Ohio Street, Lawrence, Kans.

University of Kentucky.

H. J. Beam, President; H. E. Glenn, Secretary-Treasurer, 348 Harrison Avenue, Lexington, Ky.

University of Maine.

George H. Ferguson, Jr., Secretary, University of Maine, Orono, Me.

University of Minnesota.

C. L. Swanson, President, 1716 Tyler Street, N. E., Minneapolis, Minn.

University of Missouri.

W. S. McDaniel, President; J. D. Sandker, Secretary, 407 West Broadway, Columbia, Mo.

University of Nebraska.

J. E. Applegate, President; W. H. Mengel, Secretary, University of Nebraska, Lincoln, Nebr.

University of North Carolina.

H. G. Baity, President; L. I. Lassiter, Secretary, University of North Carolina, Chapel Hill, N. C.

University of Pennsylvania.

Charles W. Foppert, President; Fred Welchy, Secretary, University of Pennsylvania, Philadelphia, Pa.

University of Pittsburgh.

L. W. Fletcher, President; J. M. Daniels, Secretary, University of Pittsburgh, Pittsburgh, Pa.

University of Texas.

Frank Cannon, President; Claude Riney, Secretary, 1908 Wichita Street, Austin, Tex.

University of Virginia.

Jack A. Gunn, Secretary and Treasurer, Box 428, University, Va.

University of Washington.

B. W. Brown, President; G. E. Large, Secretary, 4518 Eleventh Avenue, N. E., Seattle, Wash.

University of Wisconsin.

E. K. Loverud, President; L. H. Kessler, Secretary, 235 West Gilman Street, Madison, Wis.

Virginia Military Institute.

Benjamin F. Parrott, President; R. G. Hunt, Secretary-Treasurer, Virginia Military Institute, Lexington, Va.

Virginia Polytechnic Institute.

W. S. Miles, President; J. Byron Herring, Secretary, Virginia Polytechnic Institute, Blacksburg, Va.

Washington University Collimation Club.

William D. Rolfe, President; Erwin Bloss, Secretary, Washington University, St. Louis, Mo.

West Virginia University.

J. E. Wheeler, President; Milton Jarrell, Secretary, 113 Beverely Avenue, Morgantown, W. Va.

Worcester Polytechnic Institute.

Albert P. Haydon, Secretary, Worcester Polytechnic Institute, Worcester, Mass.

Yale University.

W. S. Moore, President; T. T. McCrosky, Secretary, Sheffield Scientific School, Yale University, New Haven, Conn.

NEW BOOKS*

(From March 1st to March 31st, 1922)

The statements made in these notices are taken from the books themselves, and this Society is not responsible for them.

DONATIONS TO ENGINEERING SOCIETIES LIBRARY

ECONOMICS OF ELECTRICAL DISTRIBUTION.

By P. O. Reyneau and H. P. Seelye. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 209 pp., charts, 9 x 6 in., cloth. $2.50.

In designing, constructing, or operating an electrical distribution system, the object is to provide all customers with good service at the least possible cost over the system as a whole. This result can be attained only by a careful application of economic principles to all parts of the system. This book defines these principles and indicates methods for their application. Attention is called to the need for economic study in design, the fundamental principles are explained, the usual types of problems are indicated, and methods of studying them offered.

COURSE IN ELECTRICAL ENGINEERING;

Vol. 2. Alternating Currents. By Chester L. Dawes. (Electrical Engineering Texts.) N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 526 pp., illus., 8 x 6 in., cloth. $4.00.

An elementary textbook, intended as an introduction to more advanced books. Prepared for students who have such a knowledge of direct currents as is given by Vol. 1 of this work, but with no previous study of alternating currents.

ELECTRIC SHIP PROPULSION.

By S. M. Robinson. N. Y., Simmons-Boardman Publishing Co., 1922. 274 pp., illus., diagrams, 9 x 6 in., cloth. $6.00.

This volume treats of the special questions relating to steam turbines, electric generators, induction motors, and other machines, which arise in connection with the propulsion of ships by electricity, and compares this method with others. The various systems are explained and compared. The installations on several ships of the Navy and on the *Wulsty Castle,* which illustrate the application of various systems, are described in detail.

ELECTRIC ARC WELDING.

By E. Wanamaker and H. R. Pennington. N. Y., Simmons-Boardman Publishing Co., 1921. 254 pp., illus., 9 x 6 in., $4.00.

This manual is based largely on a series of articles published in the *Railway Electrical Engineer.* It contains a large amount of practical information on many phases of the subject; descriptions of systems and their installation, phenomena of metallic and carbon welding arcs, training of welders, sequence of metal deposition for various types of joints and building-up operations, electrodes, thermal disturbances due to welding, properties of welds, efficiency of equipments, and costs. The book is confined to autogenous arc welding.

DYNAMIC AND STATIC BALANCING.

By Edward K. Hammond. N. Y., Industrial Press; Lond., Machinery Publishing Co., Ltd., 1921. 58 pp., illus., 8 x 6 in., paper. 50 cents.

A discussion of the principles of balancing, with a description of machines and methods, written in simple language. As the book is intended for shopmen, the author has avoided mathematical theory.

QUESTIONS AND ANSWERS RELATING TO DIESEL, SEMI-DIESEL,

And Other Internal Combustion Engines, Air Compressors, etc. By John Lamb. Lond., Charles Griffin & Co., Inc.; Phila., J. B. Lippincott Co., 1922. 209 pp., 4 x 5 in., cloth. 5 shillings.

A small pocketbook of practical information for steam engineers and others preparing for license examinations.

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* Unless otherwise specified, books in this list have been donated by the publishers.

OPERATING ENGINEER'S CATECHISM OF STEAM ENGINEERING.

By Michael H. Gornston. N. Y., D. Van Nostrand Co., 1922. 428 pp., diagrams, 8 x 5 in., fabrikoid. $4.00.

An elementary textbook on the construction and operation of boilers, steam engines, and turbines, heating apparatus and pumping machinery, prepared for operating engineers. The text covers the problems that confront the engineer with unusual fullness and is well indexed. The volume should be of assistance to those preparing for examination and as a pocket reference book.

JIGS AND FIXTURES.

By Albert A. Dowd and Frank W. Curtis. (Tool Engineering.) N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 293 pp., diagrams, 9 x 6 in., cloth. $2.50.

This book, the first of three on the principles underlying the design of production tools, deals with the design of jigs and fixtures for drilling, indexing, milling, profiling, broaching, riveting, etc. A chapter is devoted to vises and vise fixtures. The work deals with principles, although many interesting fixtures are shown to illustrate their use. The important points connected with the design and the relative desirability of various designs are discussed.

MODERN GASWORKS PRACTICE.

By Alwyne Meade. Second Edition. Lond., Benn Brothers, Limited, 1921. 815 pp., illus., diagrams, 10 x 7 in., cloth. 55 shillings.

The first edition of this book appeared in 1917 and quickly became out of print, through the immediate recognition of its worth as the most complete, authoritative account of modern practice extant. The new edition, although retaining all the merits of the first, has undergone an increase in bulk of 50%, through the addition of new matter, and has also been largely rewritten, to take account of the upheaval in the technique of gas-works practice in England, caused by the substitution of a calorific standard for the former candle-power standard. Every phase of the works side of gas engineering is covered, from the planning and construction of gasworks to the storage of the gas and recovery of the by-products. As a general work of reference, the book is of the greatest value to all engaged in the gas industry.

DISTRIBUTION OF GAS.

By Walter Hole. Fourth Edition. Lond., Benn Brothers, Limited, 1921. 699 pp., illus., diagrams, 10 x 7 in., cloth. 50 shillings.

This book is uniform in size with Mead's "Modern Gasworks Practice", to which it forms a fitting companion. That work treats of gas manufacture, this takes up the account at the gasholder and discusses the distribution to the consumers' appliances. The scope of the volume is a wide one. The opening chapter discusses the rights and duties of gas undertakings. Succeeding chapters treat of discharges from pipes, station governors, districting, pipes and joints of iron and steel, main-laying, valves and cocks, conduits, service pipes, meters, internal fitting, internal lighting, gas stoves and heaters, gas engines, industrial uses of gas, pressures, complaints and repairs, street lighting, high-pressure distribution, high-pressure lighting and heating, leakage, electrolysis, and fusion. The information given is thoroughly representative of current practice. Obsolete matter has been deleted in preparing this new edition and much that is new has been added.

PRACTICAL CHEMISTRY OF COAL AND ITS PRODUCTS.

By A. E. Findley and R. Wigginton. London, Benn Brothers, Limited, 1921. 144 pp., diagrams, tab., 9 x 6 in., cloth. 12 shillings 6 pence.

A collection of reliable methods for analyzing coal, coke, ammonia liquor, benzene, coal tar, water, gas, and similar products and raw materials of the gas and coke industries. Based on the course in fuel technology at Sheffield University.

GRUNDLAGEN DER FLUGTECHNIK.

By H. G. Bader. Leipzig, B. G. Teubner, 1920. 194 pp., 9 x 6 in., paper. $2.90.

A work for designers of airplanes, dealing with the calculations required and the proper methods and formulas. The text covers all the calculations that are needed in practical design and illustrate their use by application to the calculation of a concrete example. The book contains a brief bibliography.

VERVOLLKOMMNUNG DER KRAFTFAHRZEUGMOTOREN DURCH LEICHTMETALLKOLBEN.

By Gabriel Becker. München, R. Oldenbourg, 1922. 97 pp., illus., 11 x 7 in., paper. 75 marks.

The first section of this work discusses the possibilities for improving automobile construction by reducing wind resistance and weight, increasing the size and efficiency of the engines, or by perfecting the engines thermodynamically and structurally. The second and longer section gives the results of an interesting series of tests on light metal pistons, made

in 1921 at the Automobile Testing Laboratory of the Berlin Technical High School, under the direction of the author, with the assistance of the German Engine Manufacturers' Association. Extensive tests of 16 different aluminium and magnesium alloy pistons are presented and compared with tests of cast-iron and pure copper pistons.

GIESSEREI=HANDBUCH.

Herausgegeben vom Verein Deutscher Eisengiessereien Giessereiverband in Düsseldorf. München, R. Oldenbourg, 1922. 264 pp., tab., 10 x 7 in., cloth. 300 marks.

This handbook has been prepared by the German Ironfounders' Association as a convenient compendium of data used by foundrymen. It includes the standards adopted by many European railroads, by associations, and societies, methods for the analysis of cast iron, coal, coke, slags and flue gases, physical data for iron and other materials, the German standards for cast-iron pipe, tariff, and statistical data concerning the trade, trade associations, and directors of German foundries, and foundry supply dealers.

TEXTBOOK OF FIRE ASSAYING.

By Edward E. Bugbee. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 254 pp., illus., 9 x 6 in., cloth.

This work is based on the course at the Massachusetts Institute of Technology and is intended as a college textbook; but will also be useful, the author hopes, to more mature students. An endeavor has been made to give the scientific reasons underlying the phenomena that occur and the rationale of the processes and manipulations, and to avoid the character of a mere receipt book.

PROBENAHME UND ANALYSE VON EISEN UND STAHL.

By O. Bauer and E. Deiss. Zweite Auflage. Berlin, Julius Springer, 1922. 304 pp., illus., 10 x 7 in., cloth. 472 marks.

This work presents methods for sampling and analyzing iron and steel adopted by the authors for their work at the National Testing Laboratory in Berlin. The first section, by Prof. Bauer, discusses sampling, emphasizes the importance of proper sampling, and gives much information on proper methods of taking, polishing, and etching samples for miscroscopic examination. The metallographic characteristics of the constituents of iron and steel are described and directions given for securing representative samples of iron and steel for examination. The second section, by Prof. Deiss, gives reliable methods for the accurate chemical determination of the various constituents of iron and steel. This edition has been carefully revised and enlarged.

TEXTBOOK OF MINERALOGY.

By Edward Salisbury Dana. Third Edition, Revised and Enlarged by W. E. Ford. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 720 pp., illus., 9 x 6 in., cloth. $5.00.

It is twenty-four years since the second edition of this work appeared. The changes involved in the present edition are chiefly those of addition, the general character and form of the book remaining unchanged. The methods used in the stereographic and gnomonic projections have been introduced into the section on Crystallography. The section on the optical Characters of Minerals has been rewritten. All new species have been briefly mentioned in their proper places in the section on Descriptive Mineralogy. The book endeavors to present, clearly and concisely, all the information needed by students of the science.

PETROLEUM.

By Sir Boverton Redwood. Fourth Edition. Lond., Charles Griffin & Co., Ltd.; Phila., J. B. Lipincott Co., 1922. 3 v., maps, pl., illus., tab., 9 x 6 in., cloth. $21.00.

The present edition of this work was in preparation when the author died, in 1919, and certain portions had received his final revision. The remaining portions have been revised by his friends, and the work has been seen through the press by A. W. Eastlake and Robert Redwood. The general plan of previous editions is retained, although the entire work has been reset. Commencing with an historical account of the industry, the distribution, physical and chemical properties, and origin of petroleum are discussed in Vol. 1. Vol. 2 is devoted to production, refining, transportation, storage, and distribution, and to the shale oil industry. Vol. 3 treats of testing, uses, and laws; it also contains statistics, import duties, and an extensive bibliography. This contains nearly nine thousand references; unfortunately, it seems to include few, if any, publications later than 1911.

ZIRCONIUM AND ITS COMPOUNDS.

By Francis P. Venable. (American Chemical Society: Monograph Series.) N. Y., Chemical Catalog Co., Inc., 1922. 173 pp., 9 x 6 in., cloth. $2.50.

This work contains a concise account of present knowledge of the chemistry of zirconium and its compounds with other elements. Methods for the analysis of zirconium compounds, and chapters on technical applications and patents are included. An extensive bibliography is given.

THE VITAMINS.

By H. C. Sherman and S. L. Smith. (American Chemical Society: Monograph Series.) N. Y., Chemical Catalog Co., Inc., 1922. 273 pp., pl., 9 x 6 in., cloth. $4.00.

This book discusses an important branch of food chemistry, the properties and nature of the vitamins. The chemical and physiological properties of the three generally recognized vitamins are thoroughly discussed, and a chapter is devoted to the place of the vitamins in the practical problem of providing an adequate, economical food supply. An extensive bibliography is included.

IONS, ELECTRONS, AND IONIZING RADIATIONS.

By James Arnold Crowther. Third Edition. N. Y., Longmans, Green & Co.; Lond., Edward Arnold, 1922. 292 pp., diagrams, 9 x 6 in., cloth. $4.00.

This edition has been thoroughly revised, and new matter has been added wherever necessary. It now includes the results of recent work on constants, a fuller account of positive rays, and an account of the nuclear theory of the atom. The book is intended to be a reasonably complete account of the present state of the subject, suitable for students who wish a systematic knowledge of the late developments in physics.

AGGREGATION AND FLOW OF SOLIDS.

By Sir George Beilby. Lond., Macmillan and Co., Ltd., 1921. 256 pp., pl., 9 x 6 in., cloth. 20 shillings.

The molecular structure and physical properties of matter in the solid state have engaged the author's attention for many years, and from time to time papers embodying the results from particular researches have been published. The entire series of investigations has now been collected and sifted, and the results appear in the present volumes as a consecutive whole. The book is an interesting record of actual experimental observations, many of which have important industrial applications, and a summary of the conclusions reached by the author as to the meaning of the phenomena observed. A large number of excellent photo-micrographs are included.

COMPREHENSIVE TREATISE ON INORGANIC AND THEORETICAL CHEMISTRY.

By J. W. Mellor. Vol. 1-2. Lond. and N. Y., Longmans, Green and Co., 1922. 2 v., illus., 10 x 6 in., cloth.

This treatise aims, when completed, to give a complete description of all the compounds known in inorganic chemistry and, where possible, to discuss them in the light of physical chemistry. Vol. 1 is mainly introductory. It treats of the evolution and methodology of chemistry, of chemical combination, atoms, molecules, and hydrogen and oxygen and their compounds. The second volume includes the halogens, the alkali metals and the ammonium compounds. Subjects are treated with great fullness, and authorities are given for all statements of fact. The references to original publications are very complete. The work fills an important gap in modern chemical literature and will be a necessity, not only to chemists, but to workers in the various chemical and metallurgical industries who have use for precise data concerning chemical elements and compounds. No work of similar character and completeness exists in the English language.

INTRODUCTION TO PHYSICAL CHEMISTRY.

By Sir James Walker. Ninth Edition. Lond., Macmillan and Co., Ltd., 1922. 438 pp., illus., 9 x 6 in., cloth. $4.50. (Gift of The Macmillan Co., N. Y.).

Intended for the student with some knowledge of chemistry and physics, who wishes a work that will effect a connection between the knowledge which he possesses and the works on physical chemistry. By selecting certain chapters of physical chemistry and treating the subjects contained in them at some length, with a constant view to their practical application, this book is arranged to serve as an explanatory introduction. The present edition is revised and partly rewritten.

REAL MATHEMATICS.

By Ernest G. Beck. (Oxford Technical Publications.) Lond., Henry Frowde and Hodder & Stoughton, 1922. 306 pp., diagrams, 8 x 5 in., cloth. 15 shillings. (Gift of Oxford University Press, American Branch.)

This book is intended to assist in the acquisition of a real, serviceable, sound mathematical equipment, by augmenting standard textbooks and orthodox methods of study. The author hopes it will contribute toward the adoption of a change of attitude toward mathematics by those who require it as a part of their working equipment, by showing it as an actual, tangible reality, instead of a collection of rigid and unrelated rules and formulas. The method given assists the student to visualize the various operations and processes used in mathematical calculation.

MATHEMATICAL PHILOSOPHY.

By Cassius J. Keyser. N. Y., E. P. Dutton & Co., 1922. 466 pp., 8 x 6 in., cloth. $4.70.

This course of lectures by the Adrian Professor of Mathematics at Columbia University aims to disclose fundamental connections between mathematics and philosophy. The author attempts to give an insight into the essential nature of mathematics regarded as a distinctive type of thought, to show what is characteristic and fundamental in mathematical method, acquaint readers with those of the great mathematical concepts that are available to laymen, and thus to give an understanding of mathematics in relation to the other sciences and arts.

ELEMENTS OF THE DIFFERENTIAL AND INTEGRAL CALCULUS.

By William S. Hall. Second Edition, Revised. N. Y., D. Van Nostrand Co., 1922. 250 pp., 9 x 6 in., cloth. $2.75.

This textbook is an endeavor to present the calculus and some of its important applications simply and concisely, yet fully enough to make possible the study of subjects that call for knowledge of it. In this new edition, Chapters 1, 4, and 5 have been rewritten, other revisions have been made, and many new problems added.

FACTORY ADMINISTRATION IN PRACTICE.

By W. J. Hiscox. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 214 pp., 9 x 6 in., cloth. $2.50.

Most of the books on factory administration seem to have been written by accountants for accountants, the author thinks, and. as a consequence, have disregarded factory conditions to some extent. The present work is written from the factory viewpoint, and is intended for the works manager, the foreman, and all members of the factory administrative staff. The views and schemes set forth are the results of sixteen years' practical experience with engineering firms in Great Britain. Special prominence is given to the progress system.

MANUAL OF STANDARD PRACTICE FOR THE POWER LAUNDRY WASHROOM.

By the Industrial Fellowship of the Laundryowners National Association. La Salle, Ill., Laundryowners National Assoc., 1922. 112 pp., 8 x 5 in., paper. $1.00.

For several years the Chemical Engineering Department of the Laundryowners National Association has been engaged, in co-operation with the Mellon Institute of Industrial Research, in an investigation of laundry practice. The present volume is a report of the results attained. It presents a clear statement of the best practice in the washroom, gives standard formulas for proper procedure, and discusses the supplies used in the work.

BLUE PRINTING AND MODERN PLAN COPYING.

By B. J. Hall. Lond. and N. Y., Sir Isaac Pitman & Sons, Ltd., 1921. 130 pp., illus., 8 x 5 in., cloth. $2.00.

This volume should be of interest to engineers who have plans to be copied, to installers of copying plants, and to operators. The first section of the book discusses the capabilities of contact photography and allied processes for copying drawings, as well as the proper preparation of drawings for reproduction. Section two describes the machinery and apparatus used in blue-printing plants. The concluding section deals with the layout of blue-printing rooms and methods of working. Both contact and camera processes are included.

L'ETHER ACTUEL ET SES PRÉCURSEURS.

By E. M. Lémeray. (Actualités Scientifiques.) Paris, Gauthier-Villars et Cie., 1922. 141 pp., 7 x 5 in., paper.

The author of this book, an early student of the investigations of Lorentz and Einstein, is a master of the theories of relativity and has written several summaries of them. In the present work, he traces the development of the idea of the ether, which these theories tend to modify anew. The book is the result of an extensive examination of the history of science. Beginning with the ideas of the Chaldeans and Egyptians concerning a universal spirit, the modifications due to the Greeks and Romans, the ether of Huyghens, phlogiston, caloric, the ether of Fresnel, and that of later students are described.

PRINCIPLES AND DESIGN OF FOUNDATION AIR-BRAKE RIGGING.

N. Y., Air Brake Association, 1921. 121 pp., diagrams, 9 x 6 in., paper.

In the interest of higher air-brake education, the Air Brake Association has secured from the Westinghouse Air Brake Company the right to publish this study of some of the finer points that contribute to the efficiency of air-brakes. The book is the joint product of experienced engineers and should be useful to all users and designers of brakes.

MODERN TUNNELING.

By David W. Brunton and John A. Davis. New Chapters on Railroad Tunneling, by J. Vipond Davies. Second Edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1922. 612 pp., illus., 9 x 6 in., cloth. $6.50.

This is apparently a reprint of the first edition, published in 1914, with the important addition of five chapters, comprising 157 pages, written by Mr. Davis. This addition is a notable increase in the size of the book and a most important extension of its scope and usefulness. The original book supplied up-to-date data concerning American tunneling methods and equipment, but was restricted to tunnels and adits for mines and water carriage; that is, tunnels of small size in which the heading was excavated at a single operation. The new matter in this edition deals with large tunnels for railroads and highways, both subterranean and subaqueous. Extensive bibliographies are included.

EARTHWORK IN RAILWAY ENGINEERING.

By John W. F. Gardner. (Glasgow Textbooks.) N. Y., D. Van Nostrand Co., 1922. 152 pp., illus., 9 x 6 in., cloth. $3.50.

The purpose of this book is to describe briefly, in a practical manner, the underlying principles that control earthwork undertakings, as far as they relate to general railway work. In selecting the matters to be included, the author gives preference to the points more directly affected by the construction work. Special attention is given to questions of drainage.

SANITATION AND SEWAGE DISPOSAL FOR FARMSTEADS AND COUNTRY ESTATES.

By William Paul Gerhard. N. Y., The Author. 12 pp., 9 x 6 in., paper. 30 cents.

In this essay on rural sanitation Dr. Gerhard reviews briefly the defects of customary methods of rural sewage disposal and discusses those that are possible and really sanitary.

FUNDAMENTALS OF ECONOMICAL PLUMBING.

By William Paul Gerhard. N. Y., The Author. 4 pp., 12 x 9 in., paper. 30 cents.

This pamphlet on plumbing, reprinted from the *American Architect,* makes various practical suggestions concerning plumbing materials, fittings, and methods, tending toward economy in plumbing construction.

PLUMBERS' HANDBOOK.

By Samuel Edward Dibble. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 629 pp., illus., 7 x 4 in., fabrikoid. $4.00.

A concise reference book, of pocket size, which contains practical and theoretical data on matters pertaining to plumbing and heating. The book is intended for plumbers, architects, engineers, contractors, and sheet metal workers.

HEATING AND VENTILATION.

By John R. Allen and J. H. Walker. Second Edition. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 332 pp., illus., diagrams, tables, 9 x 6 in., cloth. $3.50.

A textbook for use in engineering and architectural schools, intended also for use as a handbook by engineers and architects. A second edition has become desirable, because of the advances in the art made recently, such as the establishment of standards for ventilation and the results obtained in the research laboratory of the American Society of Heating and Ventilating Engineers. The text has been thoroughly revised and enlarged to include recent developments.

ESSENTIALS IN THE THEORY OF FRAMED STRUCTURES.

By Charles A. Ellis. N. Y. and Lond., McGraw-Hill Book Co., Inc., 1922. 330 pp., tab., 9 x 6 in., cloth. $3.50.

This textbook contains no new principles, but sets forth the fundamental ideas in a different manner from that usually adopted in textbooks. The method is that of procedure from particular cases to general ones. Each principle is introduced by illustrative numerical problems, through the study of which the student is led to develop the general expression. The book requires little use of the calculus.

HYDRAULICS OF PIPE LINES.

By W. F. Durand. (Glasgow Textbooks.) N. Y., D. Van Nostrand Co., 1921. 271 pp., diagrams, 9 x 6 in., cloth. $4.50.

Intended to give a discussion, in engineering form, of the more important hydraulic problems which arise in connection with pipe lines and pipe-line flow. No attempt is made to treat the subject structurally or descriptively. The successive chapters discuss general hydraulic principles, surge, water ram or shock, stresses in pipe lines, materials, construction, design, and oil pipe lines.

SAN FRANCISCO BAY MARINE PILING SURVEY.

Second Annual Progress Report. San Francisco, The Committee, 1922. 82 pp., pl., 9 x 6 in., paper.

During 1921, the approximate period covered by this report, attention has been directed to compiling service records for existing structures and preparing a standard form for service reports, to studying methods of construction and protection and to a biological study of the destructive agency, *Teredo navalis*. Advice on proper methods of handling and using piling, repairing, creosoting, etc., is given, accompanied by specifications for creosoted piling and lumber.

DONATIONS TO READING ROOM

HYDROELECTRICAL ENGINEERING.

By Richard Muller. N. Y., G. E. Stechert & Co., 1921. 431 pp., diagrams, pl., 10 x 6½ in., cloth. (Gift of the Author.)

In a secondary title, it is stated that this book is for hydraulic and electrical engineers, students, and others interested in the development of hydro-electric power systems. It comprises in a systematic manner those principles of hydraulic and electrical engineering, which underlie the design of water-power plants. An earnest effort has been made by the author toward a proper selection and arrangement of the subject-matter.

PRACTICAL STRUCTURAL DESIGN.

By Ernest McCullough, M. Am. Soc. C. E. Second Edition, Revised and Enlarged. N. Y., U. P. C. Book Co., Inc., 1921. 317 pp., tab., diagrams, 9 x 6 in., cloth. $3.00.

This book is intended as a text and reference work on the design of structures for engineers, architects, builders, draftsmen, and technical schools, and is especially adapted to the needs of self-tutored men.

MEMBERSHIP

(From March 1st to April 4th, 1922)

ADDITIONS

MEMBERS

Name and Address	Grade	Date of Membership.
BACKUS, RICHARD ALLISON. Engr. of Constr. with McKenzie, Voorhees & Gmelin, 342 Madison Ave., New York City (Res., 45 Prospect St., South Orange, N. J.)		Nov. 21, 1921
BARSHELL, FREDERICK BAYARD. Engr., U. S. Shipping Board, Emergency Fleet Corporation, 134 West 116th St., New York City	Jun. Assoc. M. M.	May 1, 1906 April 30, 1912 Nov. 21, 1921
BRIGGS, ROBERT WESLEY. Asst. Engr., Office of Asst. to the Pres., N. Y. C. Lines, 466 Lexington Ave., New York City	Assoc. M. M.	June 11, 1917 Jan. 20, 1922
CATON, JOHN HIRST, 3D. Director Gen., Bureau of Public Works, Santo Domingo, Dominican Republic	Assoc. M. M.	June 11, 1917 Jan. 20, 1922
CORRIGAN, GEORGE WASHINGTON. Div. Engr., S. P. Co., 5th and Central Sts., Los Angeles (Res., 1965 Milan Ave., South Pasadena), Calif.	Jun. Assoc. M. M.	Feb. 5, 1901 Oct. 5, 1904 Jan. 20, 1922
JEPPESEN, GUNNI. Structural and Mech. Engr., 2104 Birchwood Ave., Chicago, Ill.		Nov. 21, 1921
KITTREDGE, FRANK ALVAH. Senior Highway Engr., U. S. Bureau of Public Roads, Mills Bldg., San Francisco, Calif.	Jun. Assoc. M. M.	Mar. 1, 1910 Sept. 3, 1913 Oct. 12, 1921
LEWIS, FRANK REDMOND. Cons. Engr., Forney, Tex.		Sept. 12, 1921
PARKER, JOSEPH WARREN. Care, Boston Transit Comm., 1 Beacon St., Boston, Mass.		Oct. 10, 1921
SLATER, WILLIS APPLEFORD. Engr.-Physicist, Bureau of Standards, Washington, D. C.	Assoc. M. M.	June 24, 1914 Jan. 20, 1922

ASSOCIATE MEMBERS

Name and Address	Grade	Date of Membership.
ADAMS, WILLIAM GEORGE ALEXANDER. With Michigan Ave. Holding Co., Inkster, Mich.		Jan. 16, 1922
CRADDOCK, ALGERNON CHARLES BRENNAN. Dist. Engr., Public Works Dept., Shanghai Municipal Council, Shanghai, China.		Sept. 12, 1921
FELLOWS, FRED GEORGE. 1674 South Pennsylvania St., Denver, Colo.		Jan. 16, 1922
FOX, HAROLD ROBERT LESLIE. Dist. Engr., Jamaica Govt. Ry., Burlington, St. Margarets Bay, Jamaica		Jan. 16, 1922
GRAHAM, RALPH CHASE. Vice-Pres. and Engr., John Benedict Co., Suite 523, Lane Bldg. (Res., 206 Kirkwood Boulevard), Davenport, Iowa		Sept. 12, 1921
HUSSON, WILLIAM MORAGNE. Archt. and Engr., 135 Westchester Sq., New York City	Jun. Assoc. M.	June 23, 1916 Mar. 16, 1922
McNOWN, WILLIAM COLEMAN. Associate Prof., Civ. Eng., Univ. of Kansas (Res., 1734 Illinois St.), Lawrence, Kans.		Sept. 12, 1921
MARTIN, ARTHUR LOUIS LIPPARD. Supt., Frederic P. Kelley, 1116 Forty-ninth St., Brooklyn, N. Y.		Sept. 12, 1921
MONTGOMERY, ALBERTIS. Lieut., Corps of Engrs., U. S. A., 9th Engrs., Mounted, Fort Riley, Kans.	Jun. Assoc. M.	Jan. 6, 1915 Jan. 16, 1922

ASSOCIATE MEMBERS—(*Continued*)

	Date of Membership.
POLLARD, WILLARD AVERELL, JR. Lieut., C. E. C., U. S. N., U. S. Navy Mine Depot, Yorktown, Va.	Nov. 21, 1921
ROMANOWITZ, CHARLES MILLICHAMP. Sales Engr., Yuba Mfg. Co., 1448 Page St., Alameda, Calif. Jun.	Dec. 3, 1913
Assoc. M.	Jan. 16, 1922
SCHIMMELPFENNIG, CHARLES WILLIAM. Gen. Mgr., Sunlight Coal Co.; Pres., Great Lakes Dredging Co., Boonville, Ind.	Sept. 12, 1921
TAYLOR, LLOYD WEBB. Box 658, Decatur, Tex.	April 3, 1922
TU, TINPH WEITSEN. Care, Chinese Representative's Office, Technical Board, Priston, Harbin, Manchuria, China	April 3, 1922
VARNER, FULLTON ESPEY. Care, Atlanta Textile Machinery Co., 54 South Forsyth St., Atlanta, Ga.	Nov. 21, 1921

AFFILIATE

GRANT, DWIGHT ALLEN. Vice-Pres. and Gen. Supt., Mayer-Grant Co., Box 16, Oil City, Pa.	Jan. 16, 1922

JUNIORS

DE STAEBLER, HERBERT CONRAD. 2073 Railway Exchange Bldg., St. Louis, Mo.	Jan. 16, 1922
HENDERSHOT, FRED. 1404 Kimball Bldg., Chicago, Ill.	Oct. 10, 1921
WIDSTRAND, OSCAR. 511 Seventh Ave., North Troy, N. Y.	Nov. 21, 1921

DEATHS

BISSELL, FRANK EDWARD. Elected Junior, April 2d, 1884; Member, September 2d, 1891; date of death unknown.

BUSH, HARRY DEAN. Elected Member, May 2d, 1888; died March 15th, 1922.

DEGARMO, ROBERT MAX. Elected Associate Member, November 4th, 1914; died February 14th, 1922.

LAFLER, WILLIAM ARTHUR. Elected Associate Member, May 4th, 1909; died January 19th, 1922.

OSBORN, FRANK CHITTENDEN. Elected Member, October 3d, 1888; died January 31st, 1922.

RANDOLPH, LINGAN STROTHER. Elected Member, January 2d, 1890; died March 7th, 1922.

SAVAGE, JOHN RICHARD. Elected Member, June 7th, 1905; died February 25th, 1922.

WHEELER, EDGAR TRUE. Elected Member, December 7th, 1904; died March 2d, 1922.

WOOD, JOSEPH. Elected Member, April 1st, 1874; died March 4th, 1922.

Total Membership of the Society, April 4th, 1922, 10 286.

CURRENT CIVIL ENGINEERING LITERATURE

Note.—The title of this list has been changed from "Monthly List of Recent Engineering Articles of Interest" to that given above. At the same time the number of periodicals indexed has been curtailed. This has been accomplished by excluding all periodicals which are published distinctly in the interest of other branches of engineering. It is the intention to index practically all the articles in the publications listed.

A new form of classification has been adopted, which will be expanded as necessary. The same letters and numbers will always be used to indicate the same classes and subdivisions of classes, and therefore any one wishing to group the articles listed on a certain subject will find them in each Number of Proceedings under the same letter and number.

KEY TO ABBREVIATED REFERENCES TO PUBLICATIONS INDEXED*

Abbreviated References.	Publication.	Place.
Am. C. Inst	*American Concrete Institute, Proceedings* (Y.)	Detroit
A. I. E. E	*American Institute of Electrical Engineers, Journal* (M.)	New York
A. R. E. A	*American Railway Engineering Association, Proceedings* (Y.)	Chicago
A. S. T. M	*American Society for Testing Materials, Proceedings* (Y.)	Philadelphia
Am. Soc. C. E	*American Society of Civil Engineers, Proceedings* (M.)	New York
Am. Soc. Mun. Impvts	*American Society for Municipal Improvements, Proceedings* (Y.)	New York
Am. W. W. Assoc	*American Waterworks Association, Journal* (Bi-M.)	Baltimore
Am. Wood Prs. Assoc	*American Wood Preservers Association, Proceedings* (Y.)	Baltimore
Ann. P. et C	*Annales des Ponts et Chaussées* (Bi-M.)	Paris
Ann. T. P. Belg	*Annales des Travaux Publics de Belgique* (Bi-M.)	Brussels
Assoc. Ing. Gand	*Annales de l'Association des Ingénieurs sortis des Ecoles Spéciales de Gand* (Q.)	Ghent
Bost. Soc. C. E	*Boston Society of Civil Engineers, Journal* (M.)	Boston
Can. Engr	*Canadian Engineer* (W.)	Toronto
Cem. Eng	*Cement and Engineering News* (M.)	Chicago
Cornell C. E	*Cornell Civil Engineer* (M.)	Ithaca
Dock & Harbour	*Dock and Harbour Authority* (M.)	London
Eisenbau	*Der Eisenbau* (M.)	Leipsig
Eng.	*Engineering* (W.)	London
Eng. Club, St. L	*Engineers Club, St. Louis, Journal* (Bi-M.)	St. Louis
Eng. & Contr	*Engineering and Contracting* (W.)	Chicago
Eng. Inst. Can	*Engineering Institute of Canada, Journal* (M.)	Montreal
Eng. N. R	*Engineering News-Record* (W.)	New York
Engrs. Soc. Pa	*Engineers' Society of Pennsylvania, Journal* (M.)	Harrisburg
Engrs. Soc. W. Pa	*Engineers' Society of Western Pennsylvania, Journal* (M.)	Pittsburgh
Engr.	*Engineer* (W.)	London
Engrs. & Eng	*Engineers and Engineering, Engineers' Club of Philadelphia* (M.)	Philadelphia
Gen. Civ	*Le Génie Civil* (W.)	Paris
Gesund. Ing	*Gesundheits Ingenieur* (W.)	Munich
Inst. C. E	*Institution of Civil Engineers Minutes of Proceedings* (Q.)	London
Inst. Mun. & Co. Engrs	*Institution of Municipal and County Engineers, Journal* (W.)	London
Int. Ry. Assoc	*International Railway Association, Bulletin* (M.)	Brussels
Land. Arch	*Landscape Architecture* (M.)	Harrisburg
Mech. Eng	*Mechanical Engineering* (M.) *Journal of the American Society of Mechanical Engineers*	New York
Mil. Engr	*Military Engineer* (M.)	Washington
Min. & Metal	*Mining and Metallurgy* (M.) *American Institute of Mining Engineers*	New York
Mun. & Co. Eng	*Municipal and County Engineering* (M.)	Indianapolis
N. E. W. W. Assoc	*New England Water Works Association, Journal* (M.)	Boston
N. Y. R. R. Club	*New York Railroad Club, Proceedings* (M.)	Brooklyn
Oest. Ing. Arch. Ver	*Oesterreichischer Ingenieur und Architekten Verein, Zeitschrift* (W.)	Vienna
Power	*Power* (W.)	New York
Rev. Gen	*Revue Générale des Chemins de Fer* (M.)	Paris

* Y = Yearly ; Q = Quarterly ; M = Monthly ; F = Fortnightly ; W = Weekly.

Abbreviated References.	Publication.	Place.
Ry. Age	*Railway Age* (W.)	New York
Ry. Main. Engr	*Railway Maintenance Engineer* (M.)	Chicago
Ry. Rev	*Railway Review* (W.)	Chicago
Schw. Bauz	*Schweizerische Bauzeitung* (W.)	Zurich
Sci. Am	*Scientific American* (M.)	New York
Soc. Ing. Civ. Fr	*Société des Ingénieurs Civils de France, Mémoires et Comptes Rendus* (Q.)	Paris
Ver. deu. Ing	*Verein deutscher Ingenieure, Zeitschrift* (W.)	Berlin
West. Ry. Club	*Western Railway Club, Proceedings* (M.)	Chicago
West. Soc. Engrs	*Western Society of Engineers, Journal* (M.)	Chicago
Zeit. Bau	*Zeitschrift fur Bauwesen* (Q.)	Berlin
Z. d. Bauver	*Zentralblatt der Bauverwaltung* (Semi-Weekly)	Berlin

A. Applied Sciences

a. Processes of Calculation

3. Stresses and Strains

Abaques pour le Détermination des Taux de Travail dans une Poutre Rectangulaire en Béton Armé, Soumise á la Flexion Composée.* (Graphical Table for the Determination of the Working Stress in a Rectangular Beam of Reinforced Concrete, Subjected to Compound Flexure.) Victor Loup. Gen. Civ. Feb. 18, '22.

B. Applied Mechanics

a. Mechanics of Solids (Strength of Materials)

2. Elastic Solids

The Effect of Temperature on the Modulus of Elasticity and Other Properties of Metals.* Frederick Charles Lea. Inst. C. E. 1919–20, Pt. 1.

Statically Indeterminate and Non-Articulated Structures.* F. C. Lea. Eng. Serial beginning Mar. 17, '22.

Beitrag zur Berechnung dem kontinuierlichen Träger verwandter Systeme von höherem Grade statischer Unbestimmtheit, unter besonderer Berücksichtigung der Einflussflächen für die Momente.* (Contribution to the Calculation of Systems Related to Continuous Beams, of Higher Degree of Static Indeterminateness, with Special Reference to the Area of Influence for the Moments.) Kaufmann. Eisenbau. Serial beginning July, '21.

Zur Berechnung der Verdrehungsschwingungen von Wellenleitungen.* (Calculation of the Fluctuations in Torque of Shafting.) J. Geiger. Ver. deu. Ing. Nov. 26, '21.

Breitflansche Träger.* (Broad Flanged Beams.) Schaper. Eisenbau. Feb., '22.

Die Kipplast des I-Trägers.* (Tipping Load for I-Beams.) G. Unold. Eisenbau. Feb., '22.

Verdrehungsschwingungen von Wellen.* (Torsional Oscillations of Shafts.) O. Föppl. Schw. Bauz. Feb. 4, '22.

3. Jointed Systems

Einige Aufgaben über die Knickfestigkeit elastischer Stabverbindungen.* (Some Problems on the Resistance to Buckling of Elastic Connecting Bars.) Eisenbau. Serial beginning Feb., '22.

Uebergang vom reinen Druck zum Knicken.* (Transition from Pure Compression to Flexure.) Z. d. Bauver. Feb. 11, '22.

4. Riveted Systems

Calcul des Poutres à Treillis Double avec Membrures Parallèles et Montants Verticaux sur les Appuis Seulement.* (Calculation of Double Lattice Girders with Parallel Members and Vertical Uprights on the Supports Only.) Leon Legens, Gen. Civ. Jan. 7, '22.

Calcul des Poutres à Treillis Double avec Membrures Parallèles et Montants Verticaux à tous les Noeuds d'Attache.* (Calculation of Double Lattice Girders with Parallel Frames and Vertical Uprights to all the Connecting Points.) Léon Légens. Gen. Civ. Feb. 11, '22.

Ueber die Berechnung von Bogenträgern in Verbindung mit einem Streckträger (Lohseträger).* (Calculation of Arched Girders Connected with Transverse Beams.) J. Wanke. Eisenbau. Oct., '21.

Beitrag zur Berechnung von Konsolstreben.* (Contribution to the Calculation of Braces for Brackets.) F. Wansleben. Eisenbau. Dec., '21.

6. Heterogeneous Solids (Reinforced Materials)

Deflection of Reinforced Concrete Beams of Rectangular Cross Section. Frank P. McKibben. Cem. Eng. Mar., '22.

7. Pulverulent Masses (Earth Pressure)

Experiments on the Horizontal Pressure of Sand.* Ponsonby Moore Crosthwaite. Inst. C. E. 1919–20, Pt. 1.

Overturning Moment on Retaining-Walls.* Angus Robertson Fulton. Inst. C. E. 1919–20, Pt. 1.

Progress Report of the Special Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, Etc.* (Presented to the Annual Meeting, Jan. 28, 1922.) Am. Soc. C. E. Mar., '22.

b. Hydraulics

1. Processes of Measurement

Reducing Bend as Venturi Meter in Hydro-Electric Plant.* E. A. Dow. Eng. N. R. Mar. 2, '22.

2. Physical Hydraulics (Orifices, Pipes, Channels, Waves)

The Coefficient of Roughness in Corrugated-Iron Pipe. D. L. Yarnell. Eng. N. R. Mar. 2, '22.

Nouvelle Méthode pour la Determination des Courbes de Remous.* (New Method for Determining Backwater Curves.) E. Baticle. Gen. Civ. Serial beginning Dec. 3, '21.

3. Industrial Hydraulics (Hydraulic Motors, Water Power, Transmission of Water Under Pressure, Propelling and Elevating Machinery)

The Walkerburn Water Power Mechanical Storage Installation.* Eng. Serial beginning Feb. 17, '22.

The Chippawa-Queenstown Power Canal.* L. H. Burpee. Cornell C. E. Mar., '22.

Hydraulic Equipment as Affecting Power House Design. Max V. Sauer. Can. Engr. Mar. 7, '22.

Features That Increase Reliability in Hydro-Electric Plants.* R. C. Denny. Power Mar. 14, '22.

Ontario "Hydro" Condemned as Wasteful and Expensive. Eng. N. R. Mar. 16, '22.

Electrical Equipment of Hydro-Electric Plants. N. L. Devendorf. Power Mar. 21, '22.

Power Development at High Falls, Que.* A. Langlois. Can. Engr. Mar. 21, '22.

High Head Impulse Wheels at New Feather River Plant.* Albert A. Northrop. Eng. N. R. Mar. 23, '22.

Usine Hydro-Electrique de la Basse-Isère à Beaumont-Monteux (Drôme) et Transport de l'Energie Produite à St.-Etienne (Loire).* (The Lower Isère Hydro-electric Plant at Beaumont-Monteux (Drôme) and the Transmission of the Energy Produced to St.-Etienne (Loire). A. Dumas. Gen. Civ. Feb. 25, '22.

Einiges über den Ausbau der Bayrischen Grosswasserkräfte und deren Nutzung.* (On the Development of the Bavarian Large Water Powers and Their Utilization.) E. Engelmann. Oest. Ing. Arch. Ver. Jan. 20, '22.

Ueber den heutigen Stand des wasserbaulichen Versuchswesens.* (The Present Status of Hydraulic Experimental Work.) E. Meyer-Peter. Schw. Bauz Feb. 11, '22.

c. Pneumatics

2. Physical Pneumatics (Flow of Gases, Waves, Air Resistance, Action of the Wind)

Die Wechselbeziehungen zwischen Verdunstung und Diffusion und die Grösse des Diffusionskoeffizienten für Wasserdampf in Luft.* (The Correlation Between Evaporation and Diffusion and the Magnitude of the Coefficient of Diffusion for Steam in Air.) Gesund. Ing. Sept. 24, '21.

C. Materials of Construction and General Processes

a. Lime, Cement, Mortar, Concrete, Brick, Bitumen, Timber, etc.

Strength and Other Properties of Scots Pine.* Alexander Robert Horne. Inst. C. E. 1919–20, Pt. 1.

Continental Portland Cement Company Increases Capacity.* Cem. Eng. Mar., '22.

Modern Plant for Manufacturing Finished Lime.* Cem. Eng. Mar., '22.

Discussion on Tentative Specifications for Concrete and Reinforced Concrete.* (Submitted as a Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.) Am. Soc. C. E. Mar., '22.

Large Quarry Rock Crushing and Screening Plant. Hilmer F. Smith. Eng. N. R. Mar. 2, '22.

Municipal Asphalt Plant at St. Catherines, Ont.* W. P. Near. Can Engr. Mar. 7, '22.

Effect of Moisture Content on Concrete.* (From *Bulletin,* Univ. of Ill. Eng. Experiment Station.) Eng. & Contr. Mar. 22, '22.

Wisconsin Produces Aggregates Locally at Low Cost. H. G. Kuehling. Eng. N. R. Mar. 23, '22.

Blocs Athermanes à Vides Chromatiques Employés comme Matériaux de Construction.* (Athermanous Blocks with Chromatic Voids Used as Building Material.) Gen. Civ. Feb. 25, '22.

b. Metals

L'Emploi de la Tôle Ondulée pour les Coffrages en Béton Armé.* (Use of Corrugated Iron for Reinforced Concrete Sheathing.) A. de Fontaine. Gen. Civ. Jan. 14, '22.

L'Essai Mecanique des Fils d'Acier.* (Mechanical Testing of Steel Wire.) Gen. Civ. Feb. 11, '22.

e. Earthwork—Cubage—Excavating Machinery

Thrust Boring by Manual Operation.* Engr. Mar. 10, '22.

g. Execution of Works. Specifications

2. Of Concrete

Pouring Concrete Under Water. Sci. Am. Apr., '22.

3. Of Wood

Holzkonstruktionen als Ingenieurbauten.* (Wooden Structures as Engineering Problems.) F. Meyer. Schw. Bauz. Feb. 18, '22.

4. Of Metal

Aus den neuen schwedisch Belastungsbestimmungen für Eisenkonstruktionen zu Haus- Brücken- und Wasserbauten. (The New Swedish Regulations Concerning the Determination of Loads for Steel Construction in Buildings, Bridges and Hydraulic Works.) Saller. Z. d. Bauver. Apr. 9, '21.

D. Highways

a. Location

Utilizing Small Stream Valleys for Traffic Routes.* Jay Downer. Mun. & Co. Eng. Mar., '22.

c. Construction

Factors Determining the Selection of Types of Pavements for City Streets.* C. M. Pinckney. Engrs. & Eng. Feb., '22.
The Relation of City Planning and Zoning to the Selection of Type of Pavement.* Jefferson C. Grinnalds. Engrs. & Eng. Feb., '22.
The Lay-Out and Construction of the New Coast Road, Durham.* W. J. Merrett. Inst. Mun. & Co. Engrs. Feb. 11, '22.
Post-War Works at Plymouth.* T. Peirson Frank. Inst. Mun. & Co. Engrs. Feb. 25, '22.
Building and Maintaining Bituminous Macadam Roads in Franklin County, Ohio. Curtis C. Lattimer. Mun. & Co. Eng. Mar., '22.
Constructing 17¼ Miles of Brick Paved Roads in Scott County, Iowa.* H. K. Davis. Mun. & Co. Eng. Mar., '22.
Remedies for Some Common Defects in Road Construction. B. H. Piepmeier. Mun. & Co. Eng. Mar., '22.
Uses of Calcium Chloride in Illinois Highway Work. Mun. & Co. Eng. Mar., '22.
Bituminous Gravel and Sand Roads. W. D. Sohier. (Paper read before Canadian Good Roads Assoc.) Eng. & Contr. Mar. 1, '22.
Construction Features of I. W. Carr Concrete Road.* John C. Searight. Eng. & Contr. Mar. 1, '22.
Importance of Surface Finish of Concrete Roads. H. E. Breed. (Paper read before Am. Road Builders Assoc.) Eng. & Contr. Mar. 1, '22.
Material Inspection Methods of Illinois Division of Highways.* H. F. Clemmer. Eng. & Contr. Mar. 1, '22.
Recent Developments in Road Construction Details. Charles M. Upham. (Paper read before Am. Assoc. of State Highways Officials.) Eng. & Contr. Mar. 1, '22.
The Bates Experimental Road of Illinois.* Clifford Older. (Paper read before Am. Road Builders Assoc.) Eng. & Contr. Mar. 1, '22.
Six Construction Mistakes in One Concrete Road.* George L. Smith. Eng. N. R. Mar. 2, '22.
Calcium Chloride in Concrete Highway Construction.* B. H. Piepmeier and H. F. Clemmer. Eng. N. R. Mar. 9, '22.
Highway Drainage and the Application of Drainage Acts. U. W. Christie. (Paper read before Conference on Road Construction.) Can. Engr. Mar. 14, '22.

d. Maintenance

The Highway Maintenance System of Pennsylvania. W. A. Van Duzer. (Paper read before Assoc. of State Highway Officials.) Eng. & Contr. Mar. 1, '22.
Against Maintenance Guarantees for Roads and Pavements. Edward W. Brush. Eng. N. R. Mar. 2, '22.
Effect of Speed on Highways. W. G. Robertson. (Paper read before Ontario Good Roads Assoc.) Can. Engr. Mar. 14, '22.
Gravel and Stone Road Maintenance. F. Pineo. (Paper read before Conference on Road Construction.) Can. Engr. Mar. 14, '22.
Stone Roads Maintenance. E. A. James. (Paper read before Ontario Good Roads Assoc.) Can. Engr. Mar. 14, '22.
Maintenance of Gravel Roads. D. J. Kean. (Paper read before Ontario Good Roads Assoc.) Can. Engr. Mar. 21, '22.

g. Machinery and Tools

Paving Mixers and Finishing Machines. Eng. N. R. Feb. 23, '22.

h. Vehicles—Automobiles

Highway Transportation. A Symposium. Thomas H. MacDonald, William G. B. Thompson, John N. Cole, E. A. St. John, Edward C. Lunt, Harry Meixell, R. S. Parsons, and G. Wythe Munford. Am. Soc. C. E. Feb., '22.

x. Miscellaneous

Highway Transportation. A Symposium. Thomas H. MacDonald, William G. B. Thompson, John N. Cole, E. A. St. John, Edward C. Lunt, Harry Meixell, R. S. Parsons, and G. Wythe Munford. Am. Soc. C. E. Feb., '22.
Highway Transportation: A Symposium. H. E. Hilts, Frederick Stuart Greene, and Herbert S. Sisson. Discussion. T. Hugh Boorman, Samuel Whinery, John C. Trautwine, Jr., Eugene W. Stern, Henry Goldmark, and H. W. Brown. Am. Soc. C. E. Mar., '22.
Road Building in Panama. J. W. Beardsley. Cornell C. E. Mar., '22.
Road-Building in Ontario. Prevost Hubbard. (Address delivered before the Ont. Good Roads Assoc.) Can. Engr. Mar. 7, '22.
Local Pit Road-Graveling Costs and Performance.* J. A. Prior. Eng. N. R. Mar. 16, '22.
Good Roads System in Ontario. F. C. Biggs. (Address before Ontario Good Roads Assoc.) Can. Engr. Mar. 21, '22.

E. Bridges, Viaducts and Arches

b. Iron or Steel Bridges and Viaducts

Speed in Reconstruction of a Highway Bridge.* Daniel B. Luten. Mun. & Co. Eng. Mar., '22.
The Continuous Truss Bridge Over the Ohio River at Sciotoville, Ohio, of the Chesapeake and Ohio Northern Railway.* Gustav Lindenthal. Am. Soc. C. E. Mar., '22.
Weatherproofing Hudson River Bridge to Save $400 000 Annually. Mun. & Co. Engr. Mar., '22.
Verfahren zum schnellen Abbau und Einbau einer aus mehreren Blechträgerüberbauten bestehenden Brücke.* (Method for the Rapid Removal and Reconstruction of a Bridge with a Superstructure Consisting of Several Solid Web Girders.) Schaper. Eisenbau May, '21.

Die Ostrawitzabrücke in Mährisch-Ostrau.* (The Ostrawitz Bridge in Mährisch-Ostrau.) Theodor Paul. Eisenbau. Jan., '22.

c. Stone Bridges and Viaducts

The Circular Arch Under Normal Loads: Discussion.* Fred A. Noetzli and William Cain. Am. Soc. C. E. Mar., '22.
Die statische Berechnung schiefer Dreigelenkgewölbe.* (Static Calculation of Oblique Three-hinged Arches.) Walter Nakonz. Zeit. Bau. Pt. 4, '20.

d. Concrete and Reinforced Concrete Bridges and Viaducts

Building a Rib-Arch Concrete Bridge in Arkansas.* C. A. Prokes. Eng. N. R. Feb. 23, '22.
The New Street Viaduct at Dover.* Eng. Serial beginning Mar. 3, '22.
Concrete Bridges and Culverts. W. J. Moore. (From Paper presented before Eighth Annual Conference on Road Constr. for Co. Road Supts. and Engrs.) Can. Engr. Mar. 7, '22.

e. Centerings—Scaffolds

Wind Pressures at High Elevations and Their Application to Radio Towers.* R. Fleming. Eng. N. R. Mar. 16, '22.

f. Suspension Bridges—Transfer Bridges

Plan to Bridge Hudson River at Anthony's Nose.* Eng. N. R. Feb. 23, '22.
Der Windverband von Hängebrücken sehr grosser Spannweiten.* (The Windbracing of Large Span Suspension Bridges.) W. Schachenmeier. Eisenbau. Jan., '22.

g. Swing, Bascule, Lift, Floating, Oscillating Bridges; Travelling Cranes

A New Development in Bascule Bridge Design.* Ry. Age Feb. 18, '22.
New Type of Trunnion Bascule Bridge: Wabash Ry.* Eng. N. R. Mar. 2, '22.
Repairing the Rolling Parts of Two Bascule Bridges.* J. B. Hunley. Eng. N. R. Mar. 9, '22.
New Development in Bascule Bridge Design.* Eng. & Contr. Mar. 22, '22.

h. Computations, Tests, etc.

Die Ergänzungsenergie elastischer Systeme.* (The Supplementary Energy of Elastic Systems.) O. Domke. Eisenbau. May, '21.
Elastizitätsgleichungen gegenseitiger Unabhängigkeit für einige hochgradig statisch unbestimmte Systeme.* (Mutually Independent Elasticity Equations for Some Highly Static Indeterminate Systems.) Grüning. Eisenbau. Dec., '21.
Die Englischen Versuche über die Stosswirkungen in Eisenbahnbrücken.* (English Experiments on the Effect of Impact on Railroad Bridges.) Müllenhof. Eisenbau. Feb., '22.
Einfluss der Fliehkräfte bei Eisenbahnbrücken.* (The Effect of Centrifugal Forces in Railway Bridges.) Kommerell. Z. d. Bauver. Feb. 18, '22.

x. Miscellaneous

Designs and Specifications for Iowa Bridge Construction. J. H. Ames. Eng. Contr. Feb. 22, '22.
Economics of Military Bridging.* P. S. Bond. Mil. Engr. Mar.–Apr., '22.

F. Inland Waters

b. Canals (General Articles)

Proposed Great Lakes—Atlantic Canal.* Engr. Mar. 10, '22.
Method of Driving the 73 Ft. Wide, 50 Ft. High Rove Barge Canal Tunnel.* (From *Compressed Air Magazine.*) Eng. & Contr. Mar. 15, '22.
Hölzerne Leitwerke am Dortmund-Ems-Kanal.* (Wooden Protective Works on the Dortmund-Ems Canal.) Ellerbeck. Zeit. Bau. Pt. 1, '21.
Die Entwasserung des Kaiser-Wilhelm-Kanals und der Bau des Entwässerungssiels bei Holtenau.* (Draining the Kaiser Wilhelm Canal and the Construction of the Discharge Canal at Holtenau.) Rogge and Jordan. Zeit. Bau. Pt. 4, '21.

c. Regulation of Waterways—Volume of Discharge, Freshets, Floods, Soundings

The Flood of September, 1921, at San Antonio, Texas: Discussion. Allen Hazen and Edgar Jadwin. Am. Soc. C. E. Mar., '22.
Controlling a Mountain Torrent in Switzerland.* Karl Haller. Eng. N. R. Mar. 2, '22.
Curbing the Colorado.* Robert G. Skerrett. Sci. Am. Apr., '22.
L'Aménagement Hydraulique du Haut-Rhône. Project de Dérivation Grésin-Monthoux, avec Usine Electrique à Gresin.* (Hydraulic Regulation of the Upper Rhône Grésin-Monthoux Plan for Diversion with an Electric Plant at Grésin.) C. Gémont. Gen. Civ. Feb. 4, '22.

d. Diverting Dams

Core Studies in the Hydraulic-Fill Dams of the Miami Conservancy District.* Charles H. Paul. Am. Soc. C. E. Mar., '22.

e. Locks, Lifts, Elevators, Inclined Planes

Some Notes on the Location and Construction of Locks and Movable Dams on the Ohio River, with Particular Reference to Ohio River Dam No. 18.* William M. Hall. Am. Soc. C. E. Jan., '22.
Some Notes on the Location and Construction of Locks and Movable Dams on the Ohio River, with Particular Reference to Ohio River Dam No. 18: Discussion. Thomas P. Roberts. Am. Soc. C. E. Mar., '22.

g. Consolidation of Banks, Leakage, Maintenance of Channel, Dredging

Das Temperaturmessverfahren zur Bestimmung der Sickerwasserverluste von Kanälen.* (Determination of Loss of Seepage Water in Canals by Means of Temperature Measurements.) F. Zunker. Z. d. Bauver. Serial beginning Jan. 7, '22.

Neuere Eimerbagger für Kanalarbeiten.* (Modern Bucket Dredge for Canal Work.) Arnold Lack. Schw. Bau. Serial beginning Jan. 28, '22.

h. Boats, Barges

Eisenbeton-Kahn nach "System Züblin-Koller."* ("Zublin-Koller" Type of Reinforced Concrete Boats.) Schw. Bauz. Jan. 21, '22.

j. River and Lake Ports, Equipment

Rangoon Port Development.* J. A. Cherry. Dock & Harbour Feb., '22.

The Possibilities of Detroit as a World Port.* William H. Adams. (Paper read before Am. Assoc. Port Authorities.) Dock & Harbour Feb., '22.

k. Utilization of Inland Waterways, Freight, Capacity

Water Transportation: A Symposium. R. H. M. Robinson, Winthrop L. Marvin, Emory R. Johnson, and Samuel O. Dunn. Am. Soc. C. E. Feb., '22.

Water Transportation: A Symposium: Discussion. Gardiner S. Williams, J. E. Willoughby, John C. Trautwine, Jr., Augustus Smith, C. C. Vermeule, and B. F. Groat. Am. Soc. C. E. Mar., '22.

G. Maritime Works

a. Behaviour of Movements of the Ocean—Winds—Waves—Tides—Currents

Tidal Characteristics and Their Importance to Engineers.* G. T. Rude. Eng. N. R. Mar. 16, '22.

c. Vessels and Maritime Navigation—Lighthouses and Buoys. Various Signals

An Experimental Determination of the Effect of Varying the Angle of Incidence on the Position of the Centre of Pressure of a Curved Plate Moving Through Water.* John Purser. Inst. C. E. 1919–20 Pt. 1.

Cape Don Lighthouse, Northern Territory, Australia.* Herbert Alfred Jackson. Inst. C. E. 1919–20 Pt. 2.

Coastal Aids to Navigation in Australia: Their Administration and Recent Developments. Joshua Fielden Ramsbotham. Inst. C. E. 1919–20 Pt. 2.

New Lighthouses in Queensland.* Maurice William Mehaffey. Inst. C. E. 1919–20 Pt. 2.

Water Transportation: A Symposium. R. H. M. Robinson, Winthrop L. Marvin, Emory R. Johnson and Samuel O. Dunn. Am. Soc. C. E. Feb., '22.

American Warship Practice.* S. V. Goodall. (Paper read before Portsmouth Eng. Soc.) Eng. Serial beginning Mar. 17, '22.

d. Roads and Outer Harbors. Dikes and Jetties. Breakwaters

Notes on Wave-Action in Harbour Areas; with Special Reference to Works for Reducing It at Blyth and Whitby Harbours.* John Watt Sandman. Inst. C. E. 1919–20 Pt. 1.

Restoration of a Cyclone-Damaged Breakwater-End in Madras Harbour.* Francis Joseph Edward Spring. Inst. C. E. 1919–20 Pt. 2.

The Design of Harbours and Breakwaters with a View to the Reduction of Wave-Action within Them.* Ralph Frederick Hindmarsh. Inst. C. E. 1919–20 Pt. 1.

The Improvement of the Entrance to Sunderland Harbour, with Reference to the Reduction of Wave-Action.* Inst. C. E. 1919–20 Pt. 1.

f. Maritime Rivers and Canals. Bank Protection

Le Tracé du Chenal Maritime dans l'Estuaire de la Seine.* (Plan of the Maritime Channel in the Estuary of the Seine.) Gen. Civ. Feb. 18, '22.

g. Dredges and Dredging. Force Pumps. Refloating and Removing Wrecks. Ice-Breakers

A Ship Without a Bottom. Robert G. Skerrett. Sci. Am. Apr., '22.

h. Wharves. Mooring Buoys. Harbor Equipment

Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators.* R. E. Knight. (Paper read before Inst. Mech. Engrs.) Dock & Harbour Mar., '22.

i. Harbors (General Articles)

Whitby Harbour Improvement. James Mitchell. Inst. C. E. 1919–20 Pt. 1.

The Area of Water Surface as a Controlling Factor in the Condition of Polluted Harbor Waters: Discussion. W. C. Purdy, Allen Hazen, and Warren R. Borst. Am. Soc. C. E. Mar., '22.

A Criticism of the New Development Scheme for the Port of Rangoon.* George C. Buchanan. Dock & Harbour. Mar., '22.

Petrograd Harbour.* Dock & Harbour Mar., '22.

Harbour Extension Works at Casablanca, Morocco.* Dock & Harbour Mar., '22.

L'Extension du Port de Marseille et l'Aménagement de l'Etang de Caronte.* (Extension of the Port of Marseille and the Improvement of the Caronte Pond.) M. Bezault. Rev. Gen. Feb., '22.

H. Railroads, Street and Interurban Railways, Automobiles, Aeronautics

a. Railroads

1. General Articles

Railroad Transportation: A Symposium. Howard Elliott, W. N. Doak and F. A. Molitor. Am. Soc. C. E. Feb., '22.
Maintenance in 1921 Failed to Meet Railway Needs. Julius H. Parmelee. Eng. N. R. Mar. 9, '22.
Problem of the Government Railways in Canada.* W. T. Jackman. Ry. Age Mar. 11, '22.
Purchasing on Specifications Viewed from Various Angles. (Abstract of paper read before the New England Railroad Club.) H. P. Hass. Ry. Rev. Mar. 18, '22.
Railway Appliance Exhibition Crowds the Coliseum. Ry. Rev. Mar. 18, '22.
The Railway Engineering Convention.* Ry. Rev. Mar. 18, '22.
Les Chemins de Fer dans les Accords de l'Allemagne avec la France et la Pologne et dans le Traité entre la France et le Gouvernement d'Angora.* (Railroads in the Agreements of Germany with France and Poland and in the Treaty between France and the Government of Angora). Marcel Peschaud. Rev. Gen. Feb., '22.
Projet d'un Nouveau Régime pour les Chemins de Fer Espagnols. (Proposed New Regime for the Spanish Railways.) Gen. Civ. Feb. 11, '22.

2. Location

Railway Location.* Sidney Blencowe. Inst. C. E. 1919–20 Pt. 1.

3. Roadbed. Construction Work. Tunnels

The Economic Reasons for Building the Clarks Summit-Hallstead Cutoff.* George J. Ray. West. Soc. Engrs. Mar., '22.
Driving a Five-Mile Rock Tunnel for Japan Railway.* Eng. N. R. Mar. 9, '22.
Railway Ditching Machines and Performance Records.* Eng. N. R. Mar. 9, '22.
Der Mergel als Feind des Eisenbahnoberbaues.* (Marl the Foe of Railroad Superstructure.) Czygan. Z. d. Bauver. Jan. 14, '22.

4. Track

Rail-Creep.* William Prior Hales. Inst. C. E. 1919–20 Pt. 1.
Creosoting Timber on the Santa Fe Railway System. A. F. Robinson. West. Soc. Engrs. Mar., '22.
"Give Her Snoos", Yells the Boss, and the Drive Was On.* R. Van Metre. (Description of Production of Ties in the Western Mountains Where They Must Be Driven in Flood Streams.) Ry. Main. Engr. Mar., '22.
How Rail is Reclaimed on the B. & O.* S. C. Tanner. Ry. Main. Engr. Mar., '22.
Labor-Saving Methods for Cleaning Ballast.* Ry. Main. Engr. Mar., '22.
Railway Crossings Should Receive More Careful Attention.* E. D. Swift. (Abstract of paper read before M. of W. Club of Chicago.) Ry. Main. Engr. Mar., '22.
The Proper Elevation of the Outer Rail. Charles Weiss. Ry. Main. Engr. Mar., '22.
Union Pacific Builds Tie Treating Plant.* Ry. Main. Engr. Mar., '22.
Track Maintenance by Contract on the Canadian Pacific Ry. H. G. Harton. Eng. N. R. Mar. 9, '22.
Unification of Railway Gauges in Australia. Engr. Mar. 10, '22.
Diagram for Calculating Annual Cost of Cross Ties.* Eng. & Contr. Mar. 15, '22.
Railway Curves: Superelevation and Maintenance.* E. E. R. Tratman. Eng. N. R. Serial beginning Mar. 16, '22.

5. Signals and Safety Apparatus

Automatic Train Control System of General Railway Signal Co.* Ry. Rev. Mar. 11, '22.
Finnigan's Automatic Train Control.* Ry. Age Mar. 11, '22.
The Bourdette-Brookins Train Control System.* Ry. Rev. Mar. 11, '22.
The Regan Automatic Train Control Systems.* Ry Rev. Mar. 11, '22.
The Simplex Train Control System.* Ry. Rev. Mar. 11, '22.
The Union Switch & Signal Company's Automatic Train Control System. Ry. Rev. Mar. 11, '22.
Valve de Queue "Omega" pour Frein Continu Automatique à Air Comprimé.* ("Omega" Tail Valve for a Compressed Air Automatic Continuous Brake.) Gen. Civ. Jan. 7, '22.
Essais d'un Nouveau Système de Frein Westinghouse à Double Capacité.* (Tests of a New Type of Double Acting Westinghouse Brake.) Rev. Gen. Feb., '22.

6. Rolling Stock (Locomotives, Cars)

Improved Hanna Locomotive Stoker, Type H-2.* Ry. Age Feb. 18, '22.
Operating Results Show Savings by Rebuilt Power.* H. F. Grewe. Ry. Age Feb. 18, '22.
Simplified System of Car Accounting Saves Large Expense.* J. W. Fox. Ry. Rev. Feb., 25, '22.
Chilean Railways' Electric Passenger Locomotives.* Ry. Age Mar. 4, '22.
The Nottingham Carriage and Wagon Works of Messrs. Cammell Laird and Co., Limited.* Eng. Mar. 10, '22.
Rolled Steel Trailer Wheels for Locomotives.* Ry. Age Mar. 11, '22.
Use of Hard Rubber Battery Jars in Car Lighting.* A. E. Voight. Ry. Age Mar. 11, '22.
Another Advance in Gasoline Rail Car Construction.* Ry. Rev. Mar. 18, '22.
Articulated Trains.* Sci. Am. Apr., '22.
Automotrice à Essence et à Deux Essieux pour Chemins de Fer d'Intérêt Local.* (A Gasoline Rail Motor Car with Two Axles for Local Railroads.) G. Tartary. Gen. Civ. Feb. 4, '22.
Widerstände, Gleisbremsen und Aufzeichnung des Bewegungsvorganges der vom Ablaufberg rollenden Wagen.* (Resistances, Track Brakes and Representation of the Process of Motion of Cars Running Down Hill.) W. Müller. Z. d. Bauver. Jan. 28, '22.

7. Use of Electricity

Rotary Converters and Railway Electrification.* F. P. Whitaker. (Abstract of paper read before the Inst. of Elec. Engrs.) Engr. Feb. 24, '22.
Effects of Electric Power Used for Traction.* Chas. F. Scott. Ry. Age Mar. 18, '22.

8. Stations. Engine Houses. Shops. Terminals

An Engine Terminal for Economical Operation. G. W. Tutan. Ry. Age Feb. 25, '22.

New Southern Pacific Terminal Building in San Francisco.* Ry. Rev. Feb. 25, '22.

Novel Methods Feature Turntable Renewal.* R. G. Aylsworth. Ry. Main. Engr. Mar., '22.

Establishing Icing Facilities (R. R. Refrigeration Plant) on a Large Scale. W. C. Phillips. Ry. Age Mar. 4, '22.

Railway Mail Terminal Will Handle Large Tonnage.* Ry. Age Mar. 4, '22.

Improved Lighting and Ventilation for Railway Freight Houses.* G. P. Richardson. Eng. N. R. Mar. 9, '22.

Pere Marquette R. R. Builds New Division Terminal.* Eng. N. R. Mar. 9, '22.

Katy Builds Freighthouse of Fireproof Construction.* Ry. Age Mar. 11, '22.

New Railway Mail Terminal in Chicago.* Ry. Rev. Mar. 11, '22.

The New Chicago Passenger Station of the Illinois Central R. R. Eng. & Contr. Mar. 22, '22.

9. Technical and Commercial Use

Container System Creates Freight Service. Ry. Age Feb. 25, '22.

10. Accidents

Railway Bridge Wreck Charged to Crushing of Pier. (Abstract of Report by Bureau of Safety of the Interstate Commerce Comm.) Eng. N. R. Mar. 9, '22.

x. Miscellaneous

Plans for N. R. A. A. Exhibit Complete.* Ry. Main. Engr. Mar., '22.

Let Railways Operate Boat Lines, Army Engineer Advises. Lansing H. Beach. (Abstract of address before National Rivers and Harbors Congress.) Ry. Rev. Mar. 18, '22.

American Railway Engineering Convention.* Eng. N. R. Mar. 23, '22.

b. Special Railroads

2. Aerial Railroads (Funicular, Monorail)

Les Transporteurs Aériens à Cables. Emploi des Propriétés de la Chaînette. Action des Charges Isolées.* (Suspended Cable-ways. Use of the Properties of the Catenary. The Action of Isolated Loads.) Cretin. Gen. Civ. Serial beginning Jan. 28, '22.

3. Narrow Gauge. Light Railways

The Work Done by Railway Troops in France during 1914–19.* David Lyell. Inst. C. E. 1919–20 Pt. 2.

A Pump-Power Railroad.* Andrew Goobeck. Sci. Am. Apr., '22.

x. Miscellaneous

Transportation Problem Paramount in Plant Construction.* Eng. N. R. Mar. 23, '22.

c. Ferry Boats

The War Department Cross-Channel Train Ferry.* Frederick Owen Stanford. Inst. C. E. 1919–20 Pt. 2.

d. Street Railways, Elevated Railways, Subways

1. General Articles

Le Chemin de Fer Métropolitain de Paris. Prolongement de la Ligne No. 3, de la Place Gambetta à la Porte des Lilas, avec Raccordement sur la Ligne No. 7, prés de la Porte du Pré-Saint-Gervais.* (The Paris Metropolitan Railway. Extension of Line No. 3 from Place Gambetta to La Porte des Lilas, with Connection to Line No. 7 near La Porte du Pre-Saint Gervais.) L. Biette. Gen. Civ. Feb. 4, '22.

3. Roadbed (Grading Construction Work) Elevated Structure

Storage Yard for Subway Trains.* Arthur E. Clarke. Cornell C. E. Mar., '22.

5. Rolling Stock

Street Railway Used for Freight Container Service.* Eng. N. R. Feb. 23, '22.

Gasoline Motor Cars with Four-Wheel Drive.* Ry. Age Mar. 18, '22.

e. Automobiles

2. Internal Combustion Engine Automobiles

Tracteur Monoroue, Système l'Hermite.* (Hermite Type of Mono-Wheel Tractor.) Gen. Civ. Feb. 11, '22.

f. Aeronautics

1. General Articles

La 11e Conférence de l'Air (Londres, Février 1922). (The Second Aviation Congress (London, February 1922).) A. Lesage et J. Michaut. Gen. Civ. Serial beginning Feb. 25, '22.

Soaring Birdman.* Ladislas d'Orcy. Sci. Am. Apr., '22.

2. Dirigible Balloons

La Résistance des Grands Dirigeables et les Services de Transports Aériens. (The Strength of Large Dirigibles and Aerial Transportation Service.) A. Poidlouë. Gen. Civ. Feb. 18, '22.

3. Aeroplanes

The Progress of Research. R. K. Bagnall-Wild. (Abstract of paper read before Air Conference.) Engr. Feb. 10, '22.

Die neuere Theorie der Tragflügel und Luftschrauben. (Modern Theory of Supporting Wings and Air Propellers.) E. Everling. Ver. deu. Ing. Oct. 29, '21.

x. Miscellaneous

Portes Basculantes, Cintrées et Equilibrées, pour Hangars d'Aviation.* (Curved and Counterbalanced Bascule Doors for Hangars.) Gen. Civ. Feb. 11, '22.

I. Municipal Water-Works. Agricultural Engineering

a. General Articles

Revamping the Artesian Water Supply of Bryan, Ohio.* Eng. N. R. Mar. 2, '22.
Entwurf für die Wasserversorgung und Entwässerung der Stadt Ujvidek in Ungarn, jetzt Novisad in Jugoslavien.* (Plan for Water Supply and Drainage of the City of Ujvidek in Hungary, Now Novisad in Jugo-Slavia.) Emerich Forbath. Gesund. Ing. Serial beginning Oct. 15, '21.

b. Hydrology. Water Resources

Construction Progress of the Hetch Hetchy Water Supply of San Francisco, California.* M. M. O'Shaughnessy. Am. Soc. C. E. Feb., '22.
A Sanitary Survey of Lake Erie, Opposite Cleveland, Ohio, 1920.* J. W. Ellms. Am. W. W. Assoc. Mar., '22.
Wirtschaftlichkeit und Frischwasserklärung bei dem O M S-Verfahren im Gegensatz zu nebengelagerten Schlammfaulräumen. (Economy and Clarification by the O M S Method Compared with Septic Tanks.) Schieckel. Gesund. Ing. Oct. 22, '21.

c. Dams and Reservoirs

Siphon Spillways.* G. F. Stickney. Am. Soc. C. E. Feb., '22.
Waterproofing a Leaky Reservoir at Nashville, Tenn.* Eng. N. R. Feb. 23, '22.
The Relation Between Deflections and Stresses in Arch Dams: Discussion. L. Standish Hall, William A. Miller and Chauncy Wernecke.* Am. Soc. C. E. Mar., '22.
Concrete Dam 22 Feet High Built With Traveling Form.* Eng. N. R. Mar. 16, '22.
Huge Water Storage Projects for New Jersey District.* Eng. N. R. Mar. 16, '22.
Influence de l'encastrement latéral dans les grands barrages.* (The Effect of Lateral Rigidity in Large Dams.) H. Juillard. Schw. Bauz. Serial beginning Dec. 3, '21.
Vor-und Sturtzbetten an Stauanlagen mit besonderer Berücksichtigung der Wehranlagen auf angeschwemmten Untergrunde.* (Rear and Fore Aprons of Storage Dams with Special Consideration of Dams on Alluvial Subsoil.) F. W. Schmidt. Zeit. Bau. Pt. 7, '20.
Der Einfluss von Ueberfallausschnitten auf der Abmessungen von Sperren.* (The Effect of the Weir Section on the Dimensions of the Dam.) Leo Hauska. Oest. Ing. Arch. Ver. Feb. 3, '22.

d. Analysis and Purification of Water

A Comparison of the Hardness of Public Water Supplies in Massachusetts, New York and New Jersey. Waldo S. Coulter. Mun. & Co. Eng. Mar., '22.
A Facultative Spore-Forming Lactose-Fermenting Organism from Iowa Surface Waters (B. Macerans).* Jack J. Hinman, Jr., and Max Levine. Am. W. W. Assoc. Mar., '22.
Applications of Colloid Chemistry to Study of Filter Effluents.* Malcolm Pirnie. Am. W. W. Assoc. Mar., '22.
Fifteen Years of Investigations by the Laboratories of the Metropolitan Water Board.* Melville C. Whipple. Am. W. W. Assoc. Mar., '22.
Symposium on the Centralized Softening of a Public Water Supply. Mun. & Co. Eng. Mar., '22.
The Loading of Filter Plants.* H. W. Streeter. Am. W. W. Assoc. Mar., '22.
The Probable Formation of Phenolic Compounds by a Chlorinated Water in Contact with a Coal Tar Paint. C. A. Hechmer. Am W. W. Assoc. Mar., '22.
The Water Supply of the Niagara Frontier. R. C. Snowden. Am. W. W. Assoc. Mar., '22.
Water Softening as a Factor in Municipal Supply. Wm. M. Barr. Am. W. W. Assoc. Mar., '22.
Water Sanitation at Krug Park Swimming Pool, Omaha, Nebraska. R. N. Perkins. Am. W. W. Assoc. Mar., '22.
Erfahrungen über Trinkwasserversorgung im Felde und über einen neuen Trinkwasserbereiter. (Experiences with the Purification of Drinking Water in the Field and with a New Purifier for Drinking Water.) Konrich. Gesund. Ing. Jul. 2, '21.
Neun Jahre Praktische Erfahungen mit dem Chlorgas-Verfahren zur Sterilisation von Trink- und Badewasser und zur Entgeruchung, Entkeimung und Fäulnisverhinderung von Abwasser. (Nine Years' Practical Experience with the Chlorine Gas Method of Sterilization of Drinking and Bathing Water and De-odorizing, Sterilization and the Prevention of Putrefaction of Waste Water.) G. Ornstein. Gesund. Ing. Aug. 20, '21.
Die Wasserentkeimung mittels ultravioletter Strahlen im Felde.* (Sterilization of Water in the Field by Ultra-Violet Rays.) A. Heilmann. Gesund. Ing. Oct. 8, '21.

e. Distribution of Water

Water Waste Survey and Metering in Detroit City.* George H. Fenkell. Can. Engr. Feb. 28, '22.
Construction Progress in the Cleveland Division of Water. A. V. Ruggles. Am. W. W. Assoc. Mar., '22.
Determining by a Single Flow Test the Capacity of a Meter at All Pressure Losses.* Fred. B. Nelsson. Am. W. W. Assoc. Mar., '22.
Electrical Operation of Gate Valves. Peter Payne Dean. Am. W. W. Assoc. Mar., '22.
Mechanical Aids for Distribution Work in Detroit, Michigan.* W. Montgomery Mitchell. Am. W. W. Assoc. Mar., '22.
Prevention of Electrolysis Troubles in Underground Pipe Structures. E. B. Stewart. Am. W. W. Assoc. Mar., '22.
A $60 000 000 Addition to Boston District Water Supply. Eng. N. R. Mar. 2, '22.
Broken Section of Pipe Line Burned Out by Electric Torch Under 50 Ft. of Water.* William W. Brush. Eng. N. R. Mar. 2, '22.
Thin Concrete Lining Successful in Irrigation Canals.* R. C. E. Weber. Eng. N. R. Mar. 16, '22.
Condition of Wood-Stave Pipe on Reclamation Projects.* William H. Nalder (From *Reclamation Record*). Eng. N. R. Mar. 23, '22.

Nomogramm für vollaufende Kreis- und Eiprofile.* (Nomograms for Circular and Egg-Shaped Profiles at Maximum Flow.) Strobel. Gesund. Ing. May 7, '21.
Die Technische Eroberung des Lovcen. (Technical Conquest of Lovcen.) F. Schönbrunner. Oest. Ing. Arch. Ver. Serial beginning Dec. 2, '21.
Zur Dimensionierung von Druckleitungs-Fixpunkten.* (The Dimensioning of Pressure Mains.) H. Hürzeler. Schw. Bauz. Feb. 25, '22.

f. Drainage of Land

Methods and Cost of Maintenance of Drains on U. S. Reclamation Service Projects.* C. E. Lounsbery (From *Reclamation Record*). Eng. Contr. Mar. 8, '22.

J. Sewerage. Sewage and Refuse Disposal

a. Sewers and Drains

Post-War Works at Plymouth.* T. Peirson Frank. Inst. Mun. & Co. Engr. Feb. 25, '22.
The Use of Concrete Pipe for Building Storm and Sanitary Sewers.* M. W. Loving. Can. Engr. Mar. 7, '22.
Cost of Sewer Construction at Louisville, Ky.* Eng. & Contr. Mar. 8, '22.
Intercepting Sewer in the Essex Border District.* M. E. Brian. (Paper read before the Assoc. of Ontario Land Surveyors.) Can. Engr. Mar. 21, '22.
Zur Frage der zweckmässigen Anordnung von Abwasserdückern und ihrer Spülung.* (On the Question of the Suitable Arrangement and Washing of Waste Water Siphons.) Gustav O. A. Liebau. Gesund. Ing. Jul. 23, '21.
Strassensinkkasten Bauart Hollenbeck D. R. G. M. (On Street Catch-Basins, Hollenbeck Patent System.) G. Spiegelberg. Gesund. Ing. Aug. 27, '21.
Die Entwicklung und der derzeitige Stand der Kanalisation Wiens.* (The Development and Present Status of the Vienna Sewer System.) W. Voit. Gesund. Ing. Serial beginning Sept. 3, '21.
Nomogramm für vollaufende Kreis- und Eiprofile. (Nomograms for Circular and Egg-shaped Profiles at Maximum Flow.) Strobel. Gesund. Ing. May 7, '21.
Druckwasserabsenkung mittels der Abwasserkanäle in unter Hochwassereinwirkung stehenden Stadtteilen.* (Drainage of Parts of the City Subject to High Water Effects, by Means of Waste Water Canals.) W. Breitung. Gesund. Ing. Serial beginning Jun. 18, '21.
Kanalschacht-Abdeckungen für schweren Verkehr.* (Drainage Pipe Manholes for Heavy Traffic.) P. May. Gesung. Ing. Sept. 10, '21.
Ueber Strassensinkkasten.* (Street Catch-Basins.) P. May. Gesund. Ing. Oct. 1, '21.
Wirtschaftlich-technische Gesichtspunkte für den Entwurf von Kanalisationsnetzen.* (Economic Technical Viewpoints for the Design of Canalization Systems.) Friedr. Münkner. Gesund. Ing. Nov. 26, '21.
Zur Berechnung offener Abwasserkanäle.* (Calculation of Open Waste Water Canals.) Imhoff. Gesund. Ing. Dec. 17, '21.
Ueber die Bestimmung der in Sielnetzen abzufuhrenden grossten sekundlichen Regenwassermengen.* (On the Determination of the Greatest Quantity of Rainwater Drawn Off per second in a Drainage System.) Hugo Eigenbrodt. Gesund. Ing. Serial beginning Jan. 7, '22.

b. Sewage Disposal. Purification

Experiments on Grease-Interceptors.* Henry Edgar Thompson. Inst. C. E. 1919–20.
The Miles Acid Process of Sewage Treatment.* F. W. Mohlman. Engrs. Soc. W. Pa. Oct., '21.
The Design of Aeration Units and Sedimentation Tanks for the Activated Sludge Sewage Disposal Plant at Milwaukee, Wisconsin.* Darwin W. Townsend. Am. Soc. C. E. Jan., '22.
Activated Sludge Sewage Disposal Plant.* Darwin W. Townsend. Eng. Serial beginning Feb. 17, '22.
Uses of Centrifuges for Sewage Sludge Dewatering.* T. Chalkley Hatton. (From paper read before Am. Public Health Assoc.) Eng. N. R. Feb. 23, '22.
Colloid Chemistry and Its Relation to Tank Treatment of Sewage.* F. W. Mohlman and Langdon Pearse. Am. W. W. Assoc. Mar., '22.
Stream Pollution and Sewage Disposal: A Symposium: Discussion, John A. Griffin and Clarence E. Keefer. Am. Soc. C. E. Mar., '22.
German Sewage-Works for Houses and Public Buildings.* Karl Haller. Eng. N. R. Mar. 16, '22.
Clarification and Activation for Indianapolis Sewage.* C. H. Hurd. Eng. N. R. Mar. 23, '22.
Die Feldberegnung mit städtischen Abwassern unter besonderer Berücksichtigung der "Phoenix- Regen-Rieselanlage".* (Watering Fields with City Waste Water with Special Consideration of the "Phoenix" Sprinkling Apparatus.) Martin Strell. Gesund. Ing. May 28, '21.
Untersuchungen über die Wirkung der langsamen Sandfiltration.* (Investigations on the Effect of Slow Sand Filtration.) W. Hilgers and L. Lauter. Gesund. Ing. Jul. 30, '21.
Die Müllverwertung durch Schmelzung.* (The Utilization of Domestic Refuse by Fusion.) Hermann Koschmieder. Gesund. Ing. Aug. 27, '21.
Die biologische Abwasserkläranlage der Heilstätte Sülzhayn i. Harz der Norddeutschen Knappschafts-Pensionskasse Halle a. S.* (The Biological Waste Water Purifying Installation of the Sülzhayn Sanitorium in Harz of the North German Miners' Benevolent Society.) G. Ziegler. Gesund. Ing. Serial beginning Sept. 3, '21.
Unfälle durch Vergiftung mit Gasen in Kanalisationswerken. (Accidents Due to Poisoning from Gases in Sewage Works.) W. Leybold. Gesund. Ing. Dec. 31, '21.
Verhütung von Unfällen durch Gasvergiftung in Kanalisationswerken.* (Prevention of Accidents Due to Gas Poisoning in Sewage Works.) W. Leybold. Gesund. Ing. Dec. '31, '21.

c. Refuse Disposal

Die Müllbeseitigung in Leipzig. (The Removal of Domestic Refuse in Leipzig.) Willy Schmitt. Gesund. Ing. Serial beginning Feb. 11, '22.

K. Heat Engines

a. Steam Engines. Boilers

The Reversed Heat Engine as a Means of Heating Buildings.* T. B. Morley. Engr. Feb. 10, '22.
Expansion Line on the Indicator Diagram.* Power Feb. 28, '22.
The Still Engine for Marine Propulsion.* Archibald Rennie. (Paper read before the Inst. of Engrs. and Shipbuilders.) Eng. Serial beginning Mar. 3, '22.
Ideal Expansion in the Steam Engine.* Power Mar. 7, '22.
Die Verbrauchszahlen der Kolbendampfmaschinen und ihre Beurteilung.* (Consumption Figures of the Piston Steam Engine and Their Evaluation.) R. Doerfel. Ver. deu. Ing. Serial beginning Jan. 28, '22.

b. Gas and Oil Engines

Experiments on Water-Injection in a Gas-Engine and its Effect upon Heat-Distribution.* William John Walker. Inst. C. E. 1919–20 Pt. 2.
Efficiency of the Diesel Oil Engine.* L. H. Morrison. Power Feb. 28, '22.

L. Electricity

a. Production of Electricity

1. Storage Batteries and Cells
Fortschritte in der Verwendung von Akkumulatoren.* (Progress in the Utilization of Accumulators.) H. Beckmann. Ver. deu. Ing. Serial beginning Jan. 28, '22.
2. Magneto and Dynamo. Electric Machines
Ueber das Pendeln von parallel geschalteten Wechselstrom-Generatoren.* (On the Hunting of Alternating Current Generators Connected in Parallel.) J. Fischer-Hinnen. Schw. Bauz. Serial beginning Jan. 14, '22.

b. Distribution and Transmission of Electricity

1. Power Plants
Electric Power in the French Base Ports, A. E. F.* Allen E. Ransom. Mil. Engr. Mar.–Apr., '22.
Usine Hydro-Electrique de la Basse-Isère à Beaumont-Monteux (Drôme) et Transport de l'Energie Produite à St-Etienne (Loire).* (The Lower Isère Hydroelectric Plant at Beaumont (Drôme) and the Transmission of the Energy Produced to St-Etienne (Loire).) A. Dumas. Gen. Civ. Feb. 25, '22.
2. Long-Distance Transmission of Energy
Die Freiluft-Schaltstation Gösgen für 50/135000 Volt.* (The Gösgen Out-door Sub-station for 50/135000 Volts.) Schw. Bauz. Jan. 7, '22.
Zur Wahl der Stromart für Grosskraftübertragungen.* (Choice of the Kind of Current for Power Transmission.) Berthold Simon. Ver. deu. Ing. Jan. 7, '22.
3. Distribution and Wiring of Electricity
Skin Effect and Proximity Effect in Tubular Conductors.* Herbert Bristol Dwight. A. I. E. E. Mar., '22.
Cutouts in Motor Circuits and Their Location.* Edgar P. Slack. Power Mar. 7, '22.
4. Measures. Meters. Rate-Making
Transformer Connections for Power-Factor Meter.* Victor H. Todd. Power Mar. 7, '22.
Methods of Measuring Temperatures in Electrical Machinery.* S. H. Mortensen. Power Mar. 14, '22.
5. Transformers and Converters
An Analytical Investigation of the Causes of Flashing of Synchronous Converters.* E. B. Shand, A. I. E. E. Mar., '22.
Condenser Discharges Through a General Gas Circuit.* Charles P. Steinmetz. A. I. E. E. Mar. '22.
6. Safety of Electric Distribution Systems—Laws and Regulations
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AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852.

PAPERS AND DISCUSSIONS

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Vol. XLVIII. APRIL, 1922. No. 4.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

THE AMERICAN MIXED-FLOW TURBINE AND ITS SETTING

By Arthur T. Safford,* M. Am. Soc. C. E., and Edward Pierce Hamilton,† Esq.

To be Presented May 3d, 1922.

Synopsis

The Proprietors of the Locks and Canals on Merrimack River were incorporated in 1792 for the purpose of making the stream navigable from tidewater to the New Hampshire line. The development of the water power available at the Pawtucket Falls, in Lowell, Mass., was commenced by them in 1821, and since that time this power has been utilized in increasing amounts by the almost continuous addition of new and improved water-wheels. Much water-wheel history was enacted there during the Nineteenth Century. The late James B. Francis, Past-President, Am. Soc. C. E., was connected with the Proprietors of the Locks and Canals from November 22d, 1834, until his death, on September 18th, 1892, and was their Chief Engineer from 1845 to 1885; his son, the late Col. James Francis, M. Am. Soc. C. E., followed him in that position, until 1893. Uriah A. Boyden was closely connected with the developments at Lowell and the first Boyden wheel was placed in the plant of the Appleton Company, in that city. Asa M. Swain was a pattern-maker in the Lowell Machine Shop and, later, developed and built the Swain wheel, at North Chelmsford, Mass. The late Hiram F. Mills, Hon. M. Am. Soc. C. E. (successor to Col. Francis as Chief Engineer of the Proprietors of the Locks and Canals), first came to Lowell to test wheels for the Swain Company, and James Emerson was engaged to design a Prony brake and, subsequently, began his wheel testing there. Clemens Herschel, Past-President, Am. Soc. C. E., at various times, worked under the late James B. Francis, at Lowell, and as Hydraulic Engineer of the Holyoke Water Power Company, from 1879 to 1889, built the Holyoke Testing Flume in 1881.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Engr., Proprietors of Locks and Canals, Lowell, Mass.

† Milton, Mass.

The library of the Locks and Canals contains a wealth of early water-wheel history; and in view of the present interest in high-speed and high efficiency water-wheels and their settings, particularly for hydro-electric developments, it has seemed, to the present Chief Engineer, that a review of the development of the turbine runner and of water-wheel settings may be timely. Many of the so-called modern features are from a quarter to a half century old, and were common knowledge to the men of that time. It is also hoped, by this paper, to call particular attention to the splendid work of the early hydraulic engineers and millwrights.

Such a review shows that the modern high-speed runner is the result of a gradual development brought about by ever-increasing demands for more power, speed, and efficiency. A wheel of the high-speed propeller type was patented and on the market fifty years ago, but the mechanical connections through crown gears and belts favored wheels of slower speed, and it was not until the development of a generator of the umbrella type that the high-speed wheel came into its own.

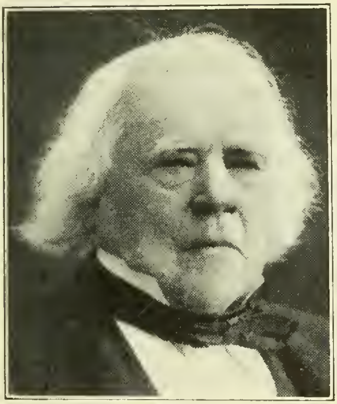
Such a review also shows that the desirability of, and the reasons for, smooth and easy passages for water-wheel channels were fully appreciated. Diffusers and draft-tubes of excellent design were in use, the scroll was well known, excellent settings were often used, and numerous examples of relatively high efficiency are on record.

During the latter part of the Nineteenth Century, quantity production with "cut and dried" installations became all too common, and too frequently the value of the proper design of the waterways and draft-tubes was overlooked. The boiler-maker ruled instead of the hydraulic engineer. Hydraulic practice during the last few years represents some improvements and a return to many of the good features developed in the middle of the last century.

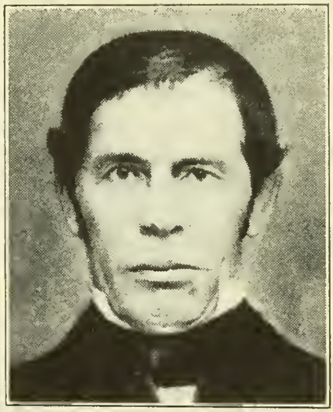
The writers have not had the benefit of the recent experimental work on wheel design, made by the water-wheel builders and their engineers, except the results of their Holyoke tests, which usually have been available. This paper does not attempt to discuss the low-speed, high-head runner. nor the remarkable development of very large units, such as some of the recent installations at Niagara Falls. In these installations, however, hydraulic conditions differ but little from those in smaller units, and the difficulties are usually mechanical and structural. It is hoped that the subject of this paper will be of sufficient interest to bring out so many additional data that the history of water-wheel design and practice in the United States may be better known than it is at the present time.

Early American Wheels

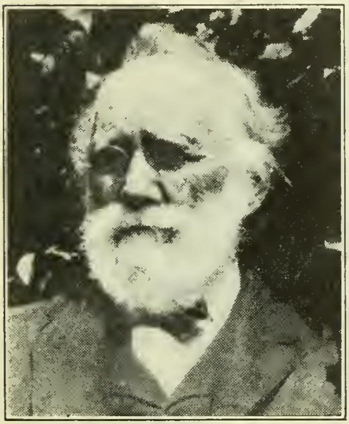
The grist-mill and the saw-mill came to this country with the first settlers. One of the very earliest water-power developments was built by Israel Stoughton, in 1634, at the lower falls of the Neponset River between Milton and Dorchester, Mass., where the head was about 8 ft. In succeeding years it was used as a grist-mill, a saw-mill, and a powder-mill, and the power is



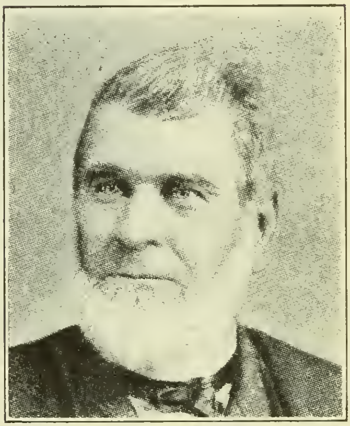
JAMES BICHENO FRANCIS.
1815–1892.



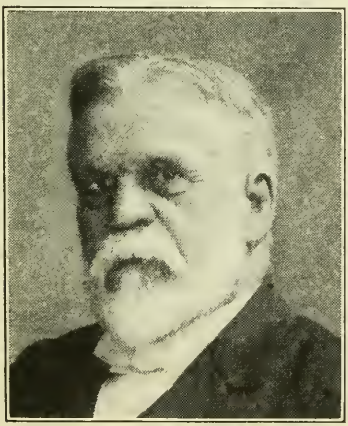
URIAH ATHERTON BOYDEN.
1804–1879.



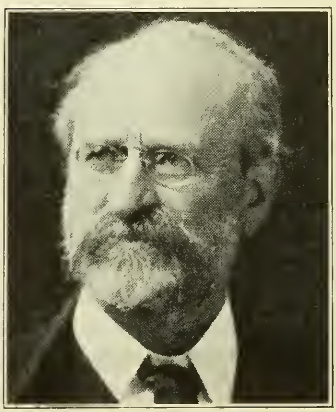
ASA METHAJER SWAIN.
1830–1908.



JAMES EMERSON.



HIRAM FRANCIS MILLS.
1836–1921.



CLEMENS HERSCHEL.
1842–

now owned by the Walter Baker Chocolate Mills. On Mill Creek on Boston Neck, there probably were tidal mills at a somewhat earlier date, but the Neponset development is interesting in that it has been in constant use for almost 300 years. The mill moved westward with the early farmer, hard on the trail of the frontiersman. The grist-mill was a most important community center, and many a town grew up around its water power. All these early wheels must have been overshot, undershot, or breast-wheels, although there may have been flutter-wheels in later days. One may read of wheels, the buckets of which were made of ox-horns. All these old wheels were built on the spot to meet the conditions of the place.

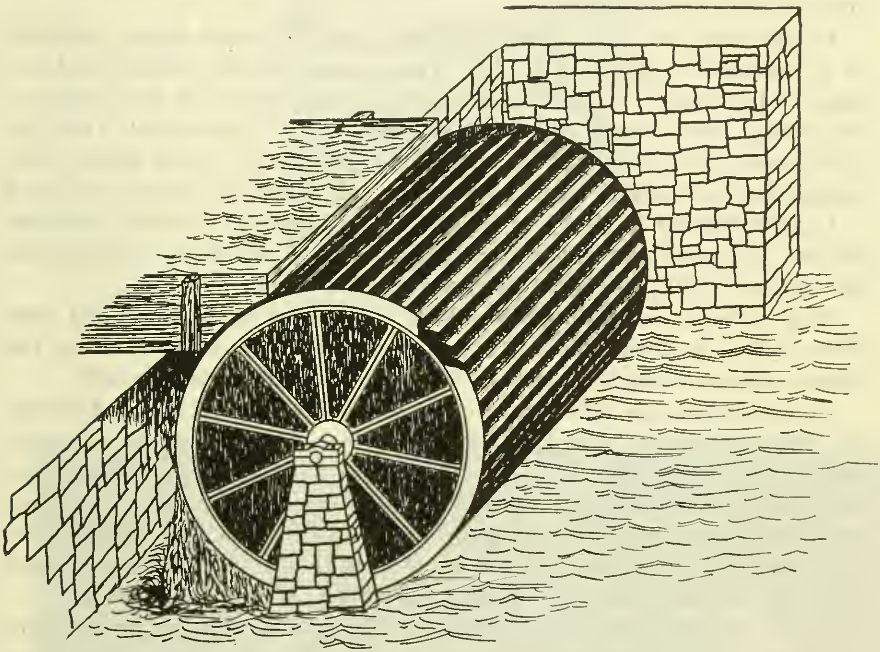


Fig. 1.—Iron Breast Wheel, Lowell, 1844.

With the coming of the Nineteenth Century, the growth of the factory system began to call for power in quantities unthought of hitherto. At first, this was met by developing the large rivers of New England on a more or less co-operative basis. The breast-wheel was used almost entirely, and as its diameter was determined by the fall—mechanical limitations fixing the former—the rivers usually were developed in stages of 10 to 20 ft. To increase their capacity, the wheels were lengthened axially and various mechanical refinements were developed. By 1840, these wheels were the common prime movers in the big textile corporations of New England. (Fig. 1.) They gave good efficiencies, but were very slow, and were particularly liable to trouble from ice. They were basicly the same as those which had been used from time immemorial. As more power was required, attention was turned toward the turbine, then existing in a crude state.

There had been in use in France from very early times—Buchetti gives the dimensions of one in the Département du Gard in 1620*—an early form of turbine known as "roue à cuve", or "tub wheel", shown in Fig. 2. This was a true reaction turbine. In 1804, Benjamin Tyler, of Lebanon, N. H., patented what was known as the "Wry Fly" wheel. The wording of the patent is obscure, but it would appear that the wheel was basicly the same as its continental ancestor. The remains of an old wheel in a saw-mill, at Bow, N. H. (Fig. 3), seem to comply closely with the description of the "Wry Fly". Another early American wheel was the Parker, invented about 1828,† which was an adaptation of the Barker or Scotch Mill. It does not seem to have come into any very general use.

In the same old mill at Bow there was a pair of spiral wheels, installed on a horizontal shaft. (Fig. 4). These were reaction wheels, and because of the rather flat blade angle, gave comparatively high speed under a low head.‡ These wheels were replaced by a pair of Rose wheels (Fig. 5), which were of the impulse type, driven by a double jet. Rose wheels were common in the Northern States in the early half of the Nineteenth Century.§

In 1838, Samuel B. Howd, of Geneva, N. Y., patented an inward discharge turbine. It seems doubtful whether he appreciated the value of centripetal flow, since, in 1842, he patented an outward-flow wheel.

Such were the early American wheels. The period of the spiral and Rose wheels cannot be fixed definitely and they may not have been as old as the others mentioned, but it is probable that they existed previous to 1840.

Transportation was very limited in the first half of the Nineteenth Century. By 1840 there were a few railroads, and a considerable network of canals over a large part of the North Atlantic States. In many ways, communities, particularly those in the interior and the more inaccessible parts of the East, were largely self-sufficient, and many of the needs were met locally. The result was that the water-wheels of the period and for some time afterward were local in origin and more or less restricted to certain communities.

This is well shown by the fact that Howd, instead of trying to manufacture his wheels, licensed builders in various localities to make them in their districts. His agents sold the rights for Middlesex County, Massachusetts, to the Proprietors of the Locks and Canals on Merrimack River for about $1 200, and this corporation sold permission to use a single wheel to Solomon Dutton, of Sudbury, for $20.

By 1840, we find a few large corporations using overshot and breast wheels of considerable capacity, and a great number of small mills all over the settled districts using undershot, overshot, and breast wheels and various forms of crude turbines. (Fig. 6.) The need for power was growing, and with the increasing development of many rivers, the question of wheel efficiency was beginning to attract attention.

* J. Buchetti, "Les Moteurs Hydrauliques Actuels", Paris, 1892.

† W. C. Hughes, "The American Miller", p. 48, Phila., 1856.

‡ David Craik, "Practical American Millwright and Miller", pp. 145–149, Phila., 1870.

§ *Ibid.*, p. 149.

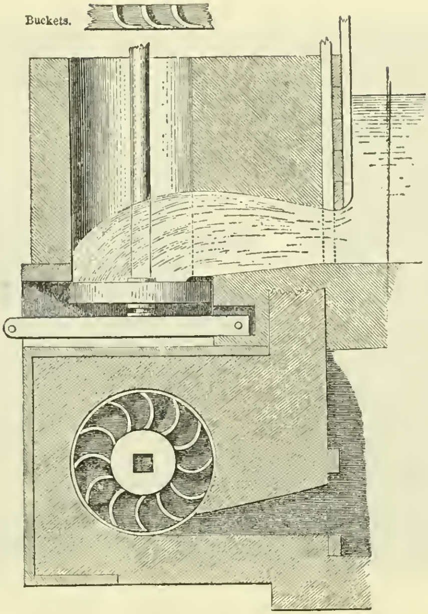


FIG. 2.—TUB WHEEL (ROUE À CUVE).

FIG. 3.—TUB WHEEL.

FIG. 4.—SPIRAL WHEEL.

FIG. 5.—FLUTTER-WHEEL AND PAIR OF ROSE WHEELS.

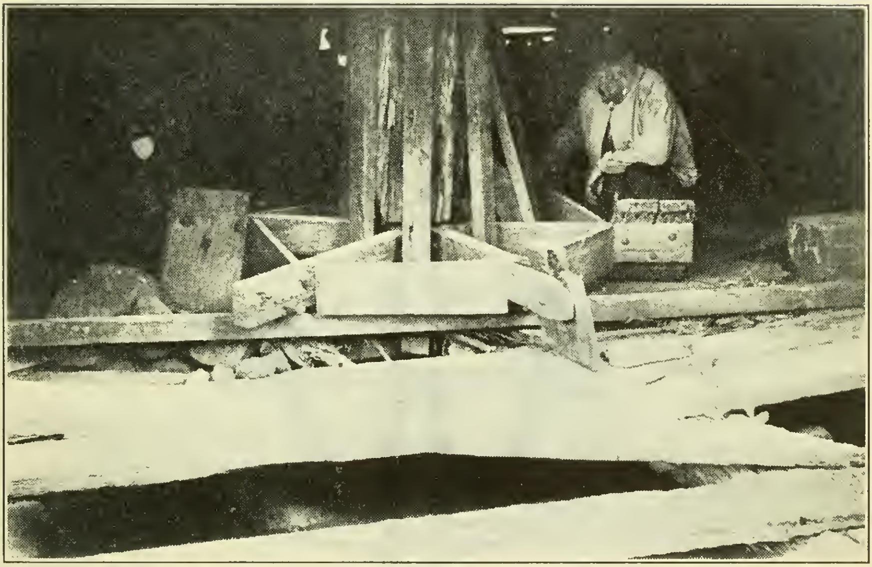


FIG. 6.—FLUTTER WHEEL.

A country, formerly devoted to farming, and importing many of its necessities from abroad, was fast spreading westward, and manufactures were developing very rapidly to meet the growing domestic needs. Since steam was still in its infancy, and water power was common throughout a large part of the country, the early factories were built where power was available. At the present time, it is interesting to study the location of the manufacturing towns of New England and to note how very many have grown up at the natural falls of the various rivers. On the large rivers, many of the developments took place where crude dams and canals had been originally built for the purpose of inland navigation.

The Fourneyron and Jonval Turbines

Fourneyron installed his first turbine at Pont sur l'Ognon (Haute Saône), in France, in 1827. (Fig. 7.) It was an outward discharge wheel in which the water was admitted axially, turned outward through 90°, and discharged. This was the first modern turbine and it was very successful.. A number were built, including a 14-in. wheel under 354-ft. fall, installed at St. Blasier in the Black Forest of Baden in 1837.*

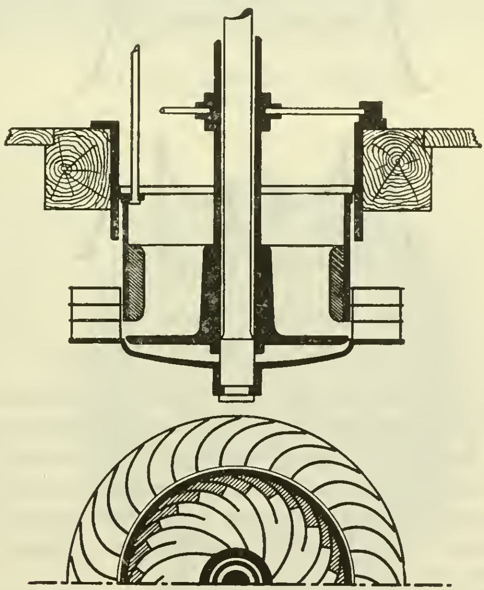


Fig. 7.—Fourneyron Turbine, 1827.

The Fountaine turbine, of 1839,† was improved by Jonval and constructed by Koechlin, in 1841.‡ It was generally known thereafter as the Jonval (Fig. 8), and was a true axial flow turbine, with the guides in a plane parallel

* Glynn, "Power of Water", p. 57. Lond., 1853.

† J. Buchetti, "Les Moteurs Hydrauliques Actuels", p. 80.

‡ J. Buchetti, "Les Moteurs Hydrauliques Actuels.".

to the runner. It was equipped with a straight draft-tube and it was well adapted to low heads.

For many years these two were the principal turbines used in Europe. In the latter part of the Nineteenth Century, the inward flow turbine, as developed by Francis and Swain, was designed and built on highly scientific lines in Germany and Switzerland.

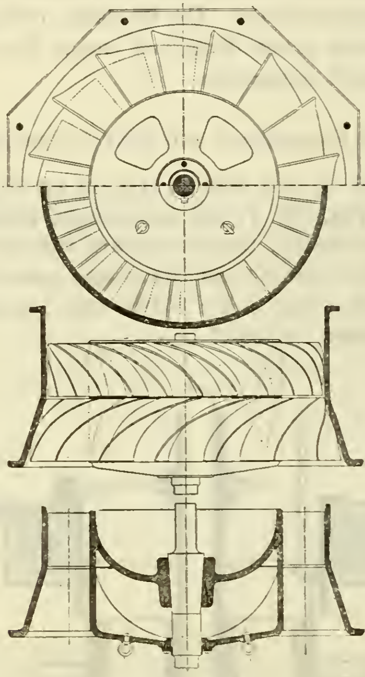


Fig. 8.—Jonval Turbine, 1841.

The Boyden and Francis Wheels

By about 1840, there were, in America, a number of embryonic turbines and a growing need for a prime mover of larger capacity and of better efficiency. In 1842, Ellwood Morris, in a paper published in the *Journal* of the Franklin Institute,* described the Fourneyron turbine as then in use in France. Turbines had been mentioned in the *Journal* in 1839 and 1840, but the paper by Morris in 1842 seems to have been the first real announcement of the outward-flow turbine in this century.

In 1844, Uriah A. Boyden designed, for the Appleton Company, of Lowell, a wheel along the lines of the Fourneyron turbine. (Fig. 9.) He improved and refined the foreign wheel both mechanically and hydraulically. His first wheel developed an efficiency of 78%,† and before many years this type of turbine was the favorite of many of the large corporations and was much used throughout New England.

* Vol. IV, Third Series (October, 1842), p. 217.

† J. B. Francis, "Lowell Hydraulic Experiments", p. 2, N. Y.; 1883.

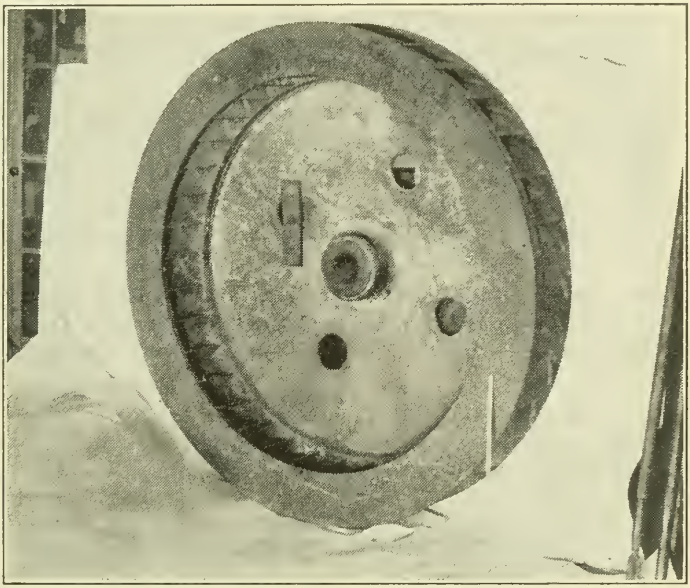


FIG. 9.—BOYDEN'S FIRST TURBINE, 1844.

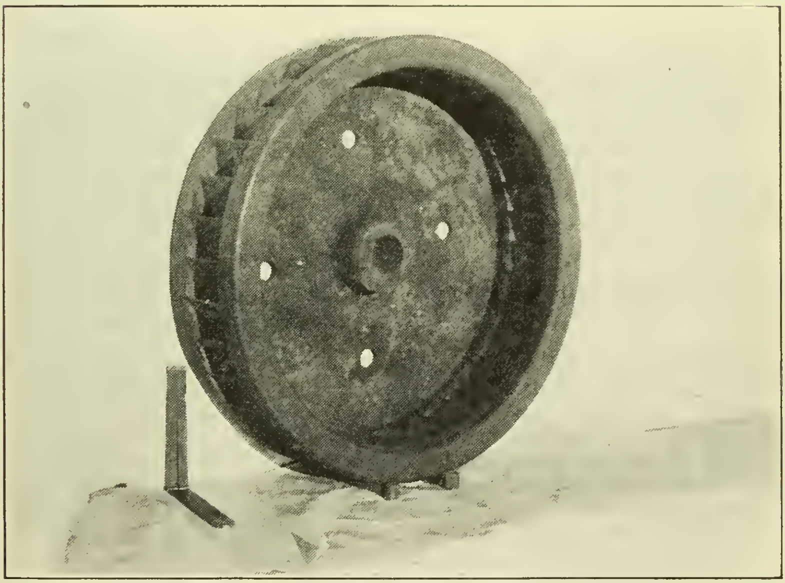


FIG. 10.—FRANCIS' FIRST EXPERIMENTAL WHEEL, 1847.

In the early part of his life, Boyden was at one time a leather splitter and had a shop in Cambridgeport, Mass. He was interested in science, and in 1826 the *New Jersey Eagle* published an article by him entitled "An Attempt to Explain the Cause of the Warmth at the Poles of the Earth". In 1838, he was Engineer of the Nashua and Lowell Railroad, but after about 1840, his main work was in hydraulics. Boyden was the inventor of the hook-gauge and he accumulated a considerable fortune from the sale of his patents on water-wheels, which, during the later years of his life, enabled him to devote his time to the study of pure science, without consideration of financial return. He was particularly interested in the velocity of light, the compressibility of water, and the study of "caloric". When he died in 1879, his fortune of about $230 000 was left to Harvard College and was used for the founding of the Harvard Observatory in Peru.

Concerning three Boyden wheels built for the Appleton Company two years later, Francis* states:

"The wooden flume, conducting the water immediately to the turbine, is in the form of an inverted truncated cone, the water being introduced into the upper part of the cone, on one side of the axis of the cone (which coincides with the axis of the turbine) in such a manner that the water, as it descends in the cone, has a gradually increasing velocity, and a spiral motion; the horizontal component of the spiral motion being in the direction of the motion of the wheel. * * * The guides, or leading curves, are not perpendicular, but a little inclined backwards from the direction of the motion of the wheel, so that the water, descending with a spiral motion, meets only the edges of the guides."

The Appleton wheels were suspended from an overhead bearing. Mr. Francis states:

"This had been previously attempted, but not with such success as to warrant its general adoption. It has been accomplished with complete success by Mr. Boyden, whose mode is to cut the upper part of the shaft into a series of necks, and to rest the projecting parts upon corresponding parts of a box. * * * It will readily be seen that a great amount of bearing surface can be easily obtained by this mode, and also, what is of equal importance, it may be near the axis. * * * The cast-iron box is suspended on gimbals, * * *." (Fig. 31.)

For a description of the diffuser which Boyden fitted to most of his wheels, Francis may again be quoted:

"The object of this extremely interesting invention, is to render useful a part of the power otherwise entirely lost, in consequence of the water leaving the wheel with a considerable velocity. It consists, essentially, of two stationary rings or discs [there was at least one example of a diffuser built integral with the runner] placed concentrically with the wheel, having an interior diameter a very little larger than the exterior diameter of the wheel; and an exterior diameter equal to about twice that of the wheel; the height between the discs, at their interior circumference, is a very little greater than that of the orifices in the exterior circumference of the wheel, and at the exterior circumference of the discs, the height between them is about twice as great as at the interior circumference; the form of the surfaces [of the disks] * * * is gently rounded, * * *. There is, consequently, be-

* "Lowell Hydraulic Experiments", 1883 edition, p. 3.

tween the two surfaces, an aperture gradually enlarging * * *. It is essential to the proper action of the diffuser, that it should be entirely under water; and the power rendered useful by it, is expended in diminishing the pressure against the water issuing from the exterior orifices of the wheel; and the effect produced, is the same as if the available fall under which the turbine is acting, is increased a certain amount. * * *

"The action of the diffuser depends upon similar principles to that of diverging conical tubes, which, when of certain proportions, it is well known, increase the discharge; * * *.

"Experiments on the same turbine, with and without a diffuser, show a gain in the coefficient of effect, due to the latter, of about 3 per cent. By the principles of living forces, and assuming that the motion of the water is free from irregularity, the gain should be about 5 per cent."

In later years, the Boyden wheels were placed at the bottom of a heavy cast-iron quarter turn. These wheels were big and heavy, and were usually set in massive cut-stone pits. They were very expensive; a 9-ft. wheel built in 1861, for the Nashua Manufacturing Company, cost $19 375.32,* or about $26 per h. p.

In 1851, Francis made a test of the power and efficiency of a Boyden wheel, built for the Tremont Mills of Lowell, which was the first scientific wheel test on a large scale. The wheel showed an efficiency of 79%; an efficiency of 88% was claimed for two of the turbines built for the Appleton Company, but the test was not so accurate. However, it is certain that the Boyden wheel, in its best form, showed an efficiency of more than 80 per cent. It had a low capacity for its size, and was of very low speed. The Tremont turbine had a specific speed of 26. The part-gate efficiency of this type of wheel was very low. The one important factor in which the Boyden wheel differed from the Fourneyron, was that its design was scientific, and every effort was made to secure hydraulic and mechanical perfection. Boyden appreciated the fact that some energy remained in the water at the time of its discharge from the runner, and to remedy this he devised the well known Boyden diffuser.

The guides and buckets of Boyden wheels were often made of composition bronze, which prolonged their lives considerably. At the plant of the Merrimack Manufacturing Company, in Lowell, there is a Boyden wheel which was installed in 1853, and which is in excellent condition and still used at certain times of year. Sixty-nine years is a long life for a prime mover, yet this wheel, except for its low speed, is much better than many wheels of much more modern design now in use in New England and elsewhere.

From a consideration of the Boyden wheel and of the earlier Howd wheel, Francis became interested in the inward flow turbine. The Proprietors of Locks and Canals, of which Company he was Engineer, secured the patent rights for the Howd wheel for the locality in which Lowell was situated. Francis first built and experimented with a small model wheel which developed an efficiency of 71% and a specific speed of 19. (Fig. 10.) In 1849, he designed a center vent wheel for the Boott Mills, which gave an efficiency of almost 80 per cent. A wheel of this type, installed in 1847, is still used to operate the head-gate hoist in the Northern Canal Gate-House in Lowell, and

* J. B. Francis, Papers, Vol. 18.

there is another (Fig. 11) in the grist-mill belonging to the Proprietors. This wheel, although theoretically better than the Boyden, was a true inward discharge wheel, and, as such, was restricted in power. In its original form, it was little used in this country and soon disappeared, but it was the foundation on which the modern American water-wheel was built.

These two American wheels—the Boyden and Francis—marked a great step forward. They were designed scientifically, full-sized drawings were made of the guides and buckets, and the path of a particle of water was studied for different relative velocities under a given head. Professor W. P. Trowbridge states that all the principles on which wheels had been designed, previous to this period, were wrong,* and that Boyden and Francis broke away from tradition and established entirely new methods. De Volson Wood† made complete computations for the original Francis wheel (Boott) and came to the conclusion that the design was excellent. The computed efficiency was 79.31 and the observed 79.37 per cent. The result of this period of scientific design has been the production of one thoroughly American wheel, the Howd wheel, as developed by Francis. This wheel was to be the forerunner of all modern reaction wheels, and the next step will be to trace its development into the mixed-flow turbine.

The "Cut and Try" Period

The period after 1860 was marked by the development of a great number of wheels of all types and combinations of types, good, bad, and indifferent, but mostly very bad. The sentiment of the period has been well expressed by "W. W. T.", as follows:

"There is no use denying that our object was to make money. We had seen these parties build an ordinary casting weighing about 300 lb. and worth when finished $30, and charge for it $231. Such profits as that were well worth working for, so we made the experiment."‡

It happened that, obtaining an efficiency of only 51%, they were honest enough to give up the attempt, but other makers, turning out even worse wheels, were less scrupulous, and continued to foist their wheels on a misguided public.

Another remark typical of the period is one attributed to Swain, inventor of the wheel of that name. Before a test of one of his wheels at Lowell, when some one said that the wheel bound in its bearings, he "guessed it would go, only put the water to it". It did not take many years of testing at Holyoke to banish that idea, and nowadays some manufacturers even have special ball-bearing bridge trees made for their Holyoke tests.

Crude and unscientific as this period was in many ways, it gave, as its result, the modern American mixed-flow turbine, and it is well worth while to examine closely the various elements that went into the melting-pot. Since this period, almost every wheel has been a combination of the tub wheel in its many forms, the center-vent Howd-Francis, and the axial-flow Jonval. It would seem, perhaps, that a little too much credit was given to the Jonval,

* "Turbine Wheels", New York, 1890.

† "Turbines", *Transactions*, Am. Soc. Mech. Engrs., Vol. XVI.

‡ *Emerson's Turbine Reporter*, January, 1876.

since almost every wheel, except the true Jonval, is merely a combination in some form or other of the first two named. All the scientific teachings of Boyden and Francis were thrown to the winds, and the great god, "Cut and Try", came into his own. If a wheel did not come up to expectations, its buckets were chipped back, up, or down, or its blades pounded, until it gave something better. Such a period could hardly be avoided, since mathematical analysis and design of turbines were unknown to the majority of early wheel makers. The beginning of the testing system at Lowell, and, later, at Holyoke, did much to relieve the situation. Before many years, a manufacturer could not avoid a wheel test and sell wheels, with the result that a poor wheel was either improved or abandoned. For a long time a few makers managed to avoid public tests, but gradually they were forced to do so, and by 1890 most of the wheels on the market were more or less satisfactory. During this period, combinations of all kinds were tried, and great ingenuity was shown, with the result that, by 1873, reported efficiencies of 90% had been reached.

One of the early wheels was the Warren scroll, which dated from about 1853. It was a slightly modified Francis runner placed in a wooden scroll case without any guides. It was merely an offshoot of the Howd-Francis wheel and, except for its casing, was of little importance.

In 1858, Swain made his first 6-in. model. This wheel was much like the Howd-Francis, except that its buckets were deeper, many in number, and curved outward from the inner discharge edge, so that the discharge was inward and downward. The diameter of the Swain wheel was still large for its capacity, and its buckets were rather shallow, but it was a really good wheel and was the direct predecessor of the modern low-speed reaction wheel. In 1870, on the advice of the late Mr. Mills, the bucket entrances were deepened and the capacity was somewhat increased. A test on a 72-in. Swain wheel by Francis, at the Boott Mills, in 1874, showed an efficiency of almost 84%, with a specific speed of 40. At this time, the wheel had no draft-tube. In 1909, C. M. Allen, M. Am. Soc. C. E., tested the power of this wheel, after a draft-tube and bevel crown-gears had been added, and the efficiency, measured by an Alden dynamometer on the jack-shaft and by current meter, was 86.1 per cent.

A power test made in July, 1921, in which a small generator was driven by a belt from the jack-shaft, showed an over-all efficiency, at the switchboard, of 73.9 per cent. After almost fifty years of use, this wheel seems still to be as good as ever; its bronze buckets are in almost perfect condition, and, to all appearances, it is capable of running for another fifty years. It is set in a wooden flume, and the water enters eccentrically, as in the Appleton wheel previously mentioned.

The Swain wheel, although one of the first of this period, was modern in every way as far as the runner was concerned. (Fig. 12.) The gate was cylinder and rather clumsy, but the part-gate efficiency was very high for that time, perhaps because the gate opened downward rather than upward. This wheel was a direct development of the Francis runner, probably by "cut and try" methods, as the inventor was a pattern-maker. However, it was really

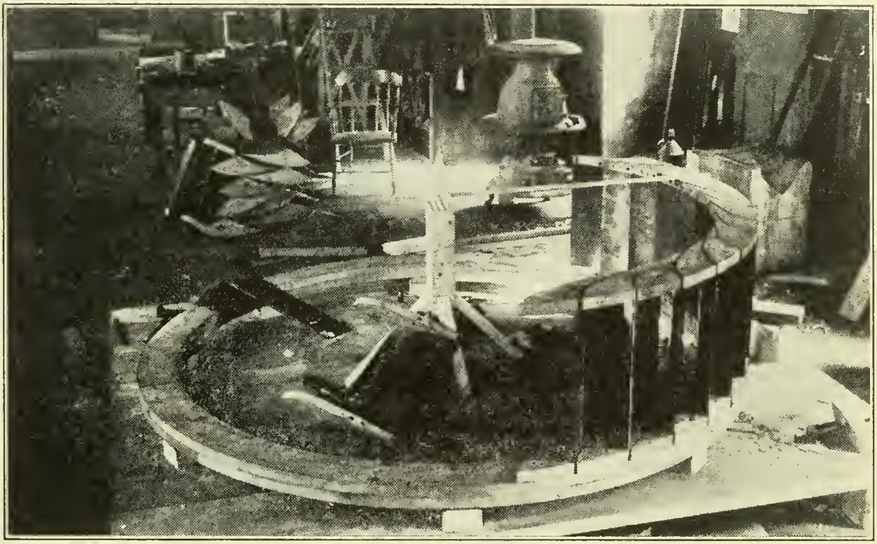


FIG. 11.—FRANCIS WHEEL IN LOCKS AND CANALS GRIST-MILL.

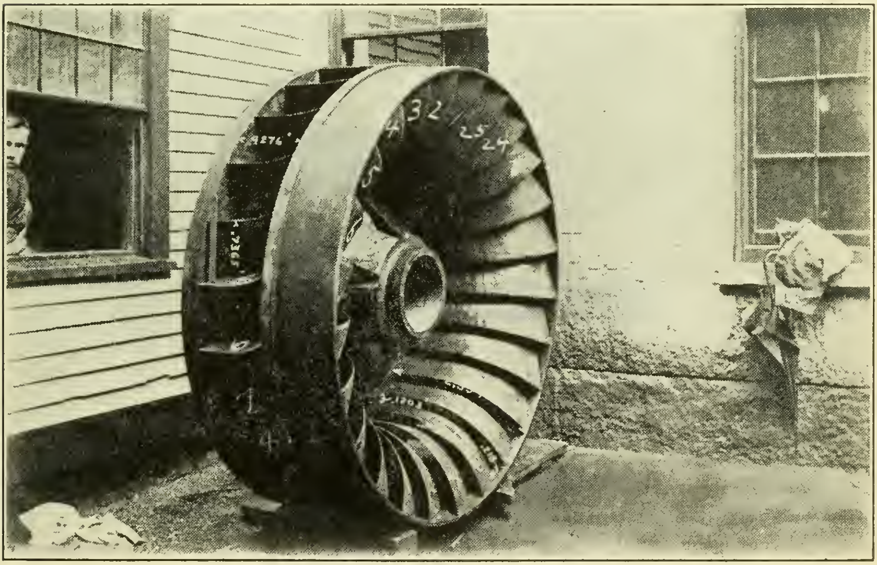


FIG. 12.—SWAIN RUNNER.

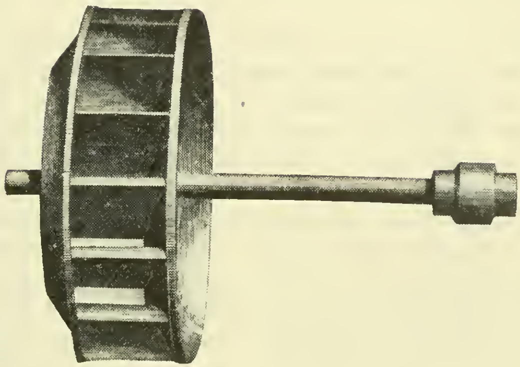


Fig. 13.—Runner of "American" Turbine 1859.

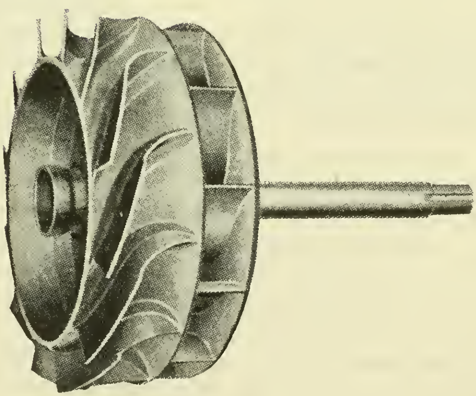


Fig. 14.—Runner of Leffler Turbine, 1862.

an excellent wheel and was the father of the modern wheel, just as the Howd-Francis was the grandfather. About 1871, a number of these wheels were installed in Lowell, replacing Boyden, center-vent, and breast wheels, and several are still in use. In all the Swain wheels, great attention was given to the smoothness of the water passages, and hydraulically they were nearly perfect. The lower step bearing, shaped as an inverted cone, diverted the downward discharge to a horizontal direction with a smooth and easy transition.

The "American" water-wheel was patented in February, 1859. It was a Francis runner, modified to give an inward and downward discharge. Its buckets were shallow, and the size was still large for the capacity. (Fig. 13.) This wheel had attained a wide distribution over the United States by 1870, particularly in small saw-mills and grist-mills. It was the first stock wheel and marked the beginning of the period of quantity production of standardized wheels. As wheel capacities were increased, the "American" was developed, through various stages to the "Improved New American" wheel, as made in recent years by the Globe Iron Works, of Dayton, Ohio, successors to the original firm of Stout, Mills, and Temple. The first "American" wheel, as tested by Emerson in 1872, showed an efficiency of about 80% with a specific speed of 25.

The firm of James Leffel and Company began building wheels at Springfield, Ohio, in 1862, and has continued to the present time. The first Leffel wheel was double; that is, it combined an inward discharge Francis runner, with another of the inward and downward type, built together in one solid piece. (Fig. 14.) This wheel attained even greater distribution than its contemporary, the "American". Equipped with wicket gates, patented by Elijah Roberts, of Rochester, N. H., in 1854,* it gave an efficiency of about 74% and a specific speed of 30.

Many manufacturers built the double wheel during this period, but all of them soon died out, except the Leffel. It is understood that the makers say that they do not quite know why the double wheel works, but it does, as shown by the fact that the double discharge Leffel Type F has recently shown an efficiency of 93% at Holyoke. It is rather interesting to note that Leffel Company still sell a considerable number of their original model, although they make several types of wheels, including one of a specific speed of 102.

The Houston wheel had a runner resembling somewhat a bevel gear, the inlet edges of the buckets being at an angle of about 45° with the shaft, the bottom diameter being the greater. This wheel was one of the better turbines of this period, showing an efficiency of as much as 88%, with a specific speed of 32. It did not have much to do with the development of the modern wheel and gradually disappeared; however, some modern high-speed wheels, especially a recent continental one, show a return to this shape of tilted bucket.

The Risdon wheel (Fig. 15) which attained an efficiency of more than 90% in 1873, marked the high point of the slow-speed, low-capacity period. Despite the fact that it had a cylinder gate, it showed an efficiency of 73%

* *Emerson's Turbine Reporter,* January, 1876.

at half load, the highest attained so far. It was an inward and downward flow wheel, and differed from the Swain mainly in that its discharge was wholly axial. The Risdon Company was the first, since Boyden, to appreciate the diffuser or draft-tube, and to apply it to its wheels. The wheel tested in 1873 gave an efficiency of 90.5% with the diffuser, and 88.8% without it. The hydraulic design of the Risdon was excellent, and it seems to have been satisfactory mechanically, although at one time, some trouble was had with the gate mechanism.

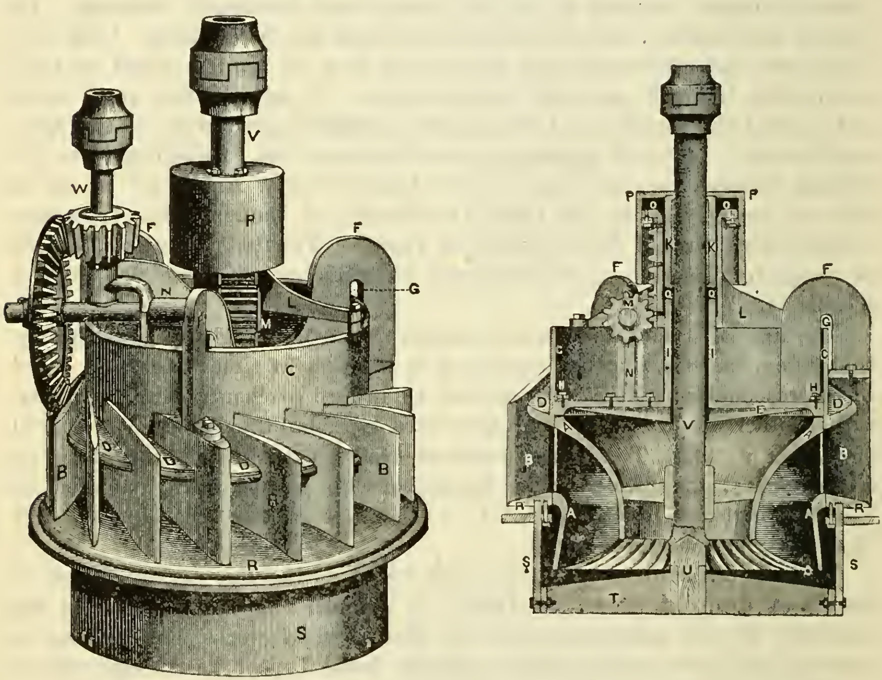


FIG. 15.—RISDON WHEEL, 1873.

Many pages would be required to describe some of the other wheels of the period such as the Angell, Barber, Blackstone, Bodine, Case, Curtis, Cook, Geyelin, Humming Bird, Humphrey, Luther Scroll, Tyler, Upham, Whitney, and others. However, they had little to do with the further development of the turbine, and, with the coming of the later wheels, soon disappeared. An especially interesting wheel of this time was the Wynkoop, a combination of an impulse wheel discharging into a reaction wheel. Its conservative makers claimed a mere 175% efficiency, but on test it showed about 55 per cent. At this time, the idea was prevalent that a double wheel would give very high efficiencies, and many of the ideas conceived bordered on perpetual motion. Of all the combination wheels, the Leffel was the only one which continued beyond the end of this period.

The Propeller Type of Runner

Recently there has been placed on the market a propeller type of runner, for which many advantages are claimed, chief of which is a high specific speed. It is proposed to demonstrate again the truth of the old adage, "there is nothing new under the sun", and to show that wheels almost exactly the same were used many years ago, and that their high speed was appreciated. It is claimed that the modern propeller wheel is axial flow. Exception is taken to this, as it is difficult to understand how, in the matter of direction of flow, the propeller wheel can be different from any modern high-speed reaction wheel. The propeller wheel, as commercially installed, is set in a wheel-case of the Francis type, the water being admitted through the usual wicket gates, in a direction approaching the tangential.

True axial flow presupposes axial delivery of the water to the casing, as in the Jonval wheel. The propeller wheel must depend on the principle of the vortex, which is formed by the tangential admission of the rapidly moving water. It is only a step farther to imagine a wheel setting in which, guides being eliminated, a scroll may be substituted, of such dimensions as to give the same direction and velocity of flow to the wheel. It is granted that this will hold under only one condition of speed and discharge. The wheel is still a propeller wheel, and it is still operating on the same principle as it did when equipped with wicket guides.

The old tub wheel merely consisted of a vertical shaft carrying a number of blades lying in planes inclined to the wheel axis. The water was admitted to the wheel with a more or less downward direction, and eccentric to the axis. Under such conditions, somewhat of a vortex action must have resulted. This type of tub wheel was a true reaction turbine. How, then, but for the addition of the draft-tube, is the modern propeller wheel different? In both cases, the water is admitted practically perpendicular to the shaft, and discharged axially, and the runner is of the same type.

In July, 1860, J. W. Truax, of Richford, Vt., patented a water-wheel known as the "Green Mountain", which, as manufactured in 1876, was as shown in Fig. 16. It was a four-bladed wheel on a vertical shaft, set eccentrically in a wooden flume. The runner had a band around it, to which were attached a number of small, inclined plane saw teeth, designed to make the leakage do work, but this does not change the fact that here is a runner identical in principle with the propeller wheel as made at the present time. Other than the maker's circular, little information can be found regarding this wheel. Apparently, its use was largely local, most of the known installations having been in Vermont. Truax, in his circular of March, 1876, states:

"What has baffled the skill and ingenuity of inventors, has been to produce a wheel that would use a large quantity of water and obtain corresponding power for the water used, and, at the same time, attain sufficient speed in the wheel itself to allow the power of the wheel to be transmitted with convenience and small outlay on light falls. These points are obtained with this wheel."

He further states that the speed of a wheel of this type depended on the incline of the blades. Not only did Truax appreciate what he had, but he also knew how he got it, which was unusual at this time.

Unfortunately, no tests of this wheel are available, and the only record of it is the maker's wheel-table, which is claimed to be the result of actual measurements. It gives a 30-in. wheel a speed of 126 rev. per min. under a head of 1 ft. Assuming that the measurement of the revolutions per minute and of the water was correct, and, furthermore, assuming an efficiency of 60%, which seems fair and reasonable in the light of the performance of similar wheels of the same period, a specific speed of 125 is obtained. If the efficiency had been only 40%, the specific speed would still be more than 100.

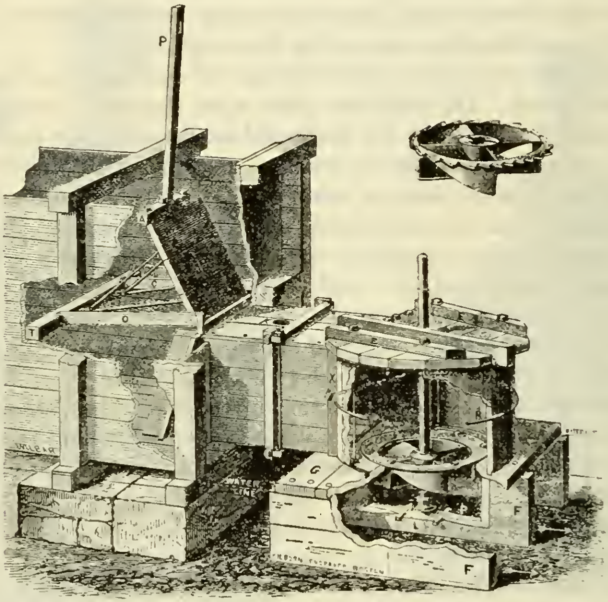


Fig. 16.—Green Mountain Propeller, 1876.

In June, 1884, at the Holyoke Water Power Company's flume, a test (No. 256) was made of a Chase Special wheel (Fig. 17), built by the Chase Turbine Manufacturing Company, of Orange, Mass. This wheel had an eight-bladed propeller runner, set, without any guides, in an iron scroll case. Here is another wheel, somewhat more modern, operating on the same principle. The buckets were less flat than in the "Green Mountain", with a consequent reduction in speed. However, it showed a good efficiency, 78.9%, with a specific speed of about 50.

In the Jonval, the blades were set radially around the periphery of a disk which left a circle of dead area around the shaft. This meant that the effective lever arm of the runner was large, with a result that the speed was necessarily low. Both the Chase wheel and the "Green Mountain" differed from the Jonval, in that their blades were directly attached to a small hub, with almost no dead area. The blades were effectively acted on by the water

to a point very close to the wheel shaft, which meant that, for a given diameter of wheel, a much higher speed could be attained.

With regard to "spiral, or screw flood wheels", David Craik,* in 1870, stated:

"Their principle of action is the same as the screw propeller, which has, in a measure, superseded the paddle-wheel in steamboats—the difference being that the propeller is driven round * * * by the steam-engine, * * * while the screw water wheel * * * is driven or revolved by the force of the passing current against its oblique vanes * * *. To comprehend this similarity better, take a screw propeller, and place its axis upon suitable bearings, and parallel with the stream in a strong, uninterrupted current, and entirely submerged, and it will furnish a motive-power * * *."

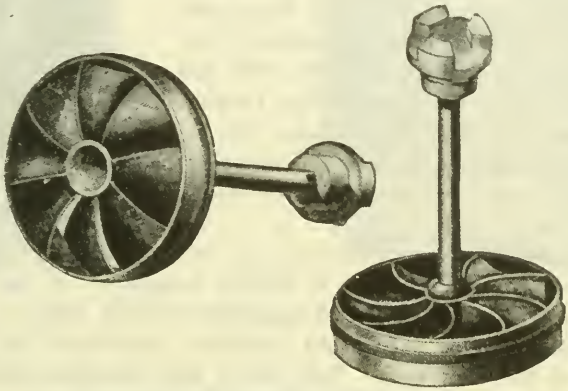


FIG. 17.—CHASE SPECIAL RUNNER, 1880.

He further states that, by this, he does not advocate using the common type of propeller for a wheel, since, being driven rather than driving, "it requires a modification in structure and details". This refers, of course, to a wheel with true axial flow, and one in which the water approaches without any whirling motion.

R. E. Horton, M. Am. Soc. C. E., states:†

"A variation of the Jonval turbine, in which the number of buckets was reduced to two, was extensively used in saw-mills in northern New York. Owing to the large openings of the buckets, ice, drift, and other obstructions could pass through this wheel without injuring it. The vanes were nearly horizontal, giving a high speed of rotation. The efficiency was very low."

This was the Austin wheel, one similar to the Truax.

THE MODERN MIXED-FLOW TURBINE

In 1876, a number of 24-in. wheels, invented by John B. McCormick, of Brookville, Pa., were sent to Holyoke to be tested. They were the development of a type of large capacity wheel, invented by John and Matthew Obenchain, and were the first of the famous "Hercules" type. One of them, tested by Emerson, showed an efficiency of 89.2% with a specific speed of

* "The Practical American Millwright and Miller", p. 150, Phila., 1870.

† *Water Supply Paper No. 180*, U. S. Geological Survey, p. 13.

48, which is 13 more than the highest previous wheel, the Risdon. A 36-in. "Hercules", tested at the present Holyoke flume in 1883, showed an efficiency of 87% in three different tests. The flow was inward, downward, and slightly outward. The buckets were much deeper than in any previous wheel and protruded below the band, thus allowing the outward discharge. (Fig. 18.) The wheel was of the cylinder gate type and the blades had fins parallel to the line of flow, that were supposed to improve the part-gate efficiency, which was 73% at half power.

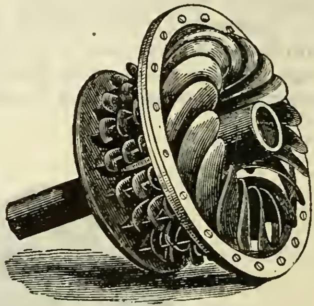


Fig. 18.—Hercules Runner, 1876.

The production of the "Hercules" ushered in a new period of wheel design. The inward flow principle of the Howd-Francis and the downward discharge of the tub and Jonval wheels had been combined in the correct proportions, and, aided by good mechanical construction, there had been evolved the American mixed-flow turbine. High speed was yet to be developed, but the beginning had been made, and, with few exceptions, all subsequent design was merely improvement over the McCormick type.

One must not forget the generations of millwrights who had worked to make this possible. It was not a sudden invention; it was merely the crystallization and modification of principles toward which all had been working. Many an old, self-trained mechanic contributed his mite to the development of this new type. This was a real American production, the result of evolution during a changing period in American history. The need arose, made itself felt, and eventually was met, not by the work of one great scientist, but by the multitudinous efforts of an army of old Yankee millwrights and machinists, many of whose names are either unknown or forgotten.

The year after the introduction of the "Hercules", Stilwell and Bierce, of Dayton, Ohio, placed the "Victor" turbine on the market. This wheel was much like the "Hercules" and had very deep buckets which hung even farther below the band than in the earlier wheel. Built with a register gate, it was of very simple and solid construction, and, although a little below the "Hercules" in efficiency, it also had a specific speed of 48. (Fig. 19.)

Both the "Hercules" and the "Victor" were later modified somewhat; the "McCormick" wheel was placed on the market by several makers, and the improved Leffel, double-discharge wheel, the "Samson", appeared. Until about 1900, these were the usual types of wheel and practically every condition necessarily was met by the selection of some one of the stock models of the several types then available. Such was the state of affairs at the beginning of the period of electrification, when higher speed and better regulation became of growing importance.

During the last few years, all effort has been devoted toward increasing the specific speed of the mixed-flow runner, without suffering a loss in efficiency. The bottom, or discharge, diameter has been greatly increased, with

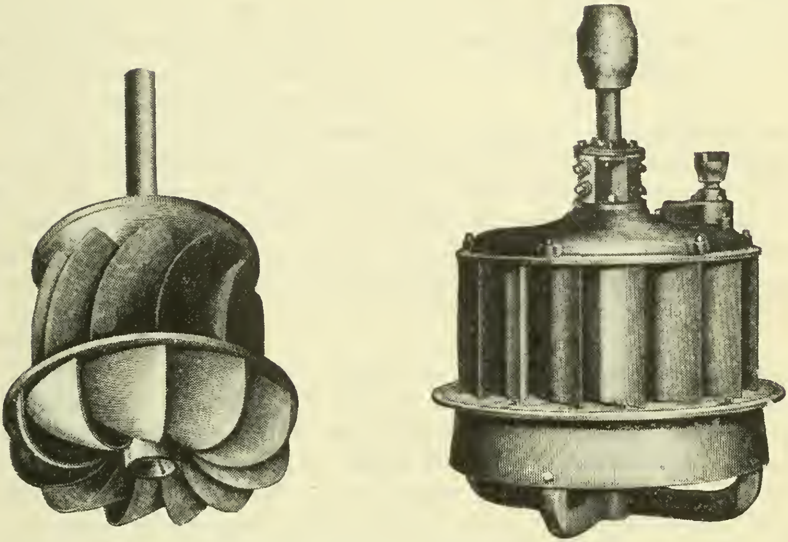


FIG. 19.—VICTOR TURBINE, 1877.

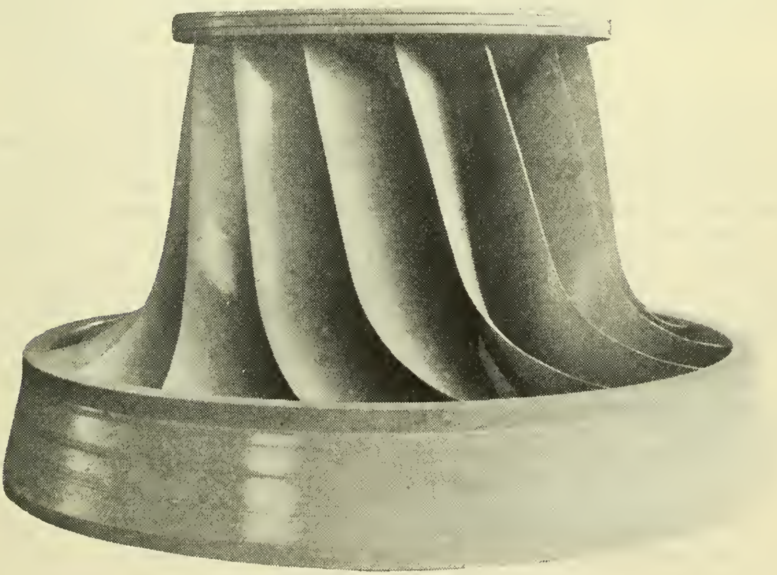


FIG. 20.—MODERN HIGH-SPEED RUNNER.

the result that the modern high specific speed runner with a nominal diameter of 30 in., has a maximum diameter of more than 40 in. The buckets no longer protrude much below the band, and the inlet edges of the buckets usually slant, so that the clearance between the guides and the buckets is considerably more at the top than at the bottom. Fig. 20 shows one of the best of the modern high-speed runners, which gives an efficiency of more than 90%, and a specific speed of 102.

In the United States there seems to be a general belief, especially among some of the large water-wheel manufacturers, that practically all the development of the modern water-wheel has taken place within the last twenty years and has been the result of the introduction of foreign practice in water-wheel design. Practically all development abroad has been in Switzerland and in Germany. In France, where the first turbines of record are found, comparatively little has been done toward the development of the modern high-speed wheel.

The Germans developed the mixed-flow turbine to some extent, but they did not create it—that honor belongs to the United States. The turbines of Fourneyron, Fountaine, and Jonval were all French in conception, although it has been said that Henschel, of Cassel, Germany, deserves the credit for the axial flow wheel, rather than Jonval, whom he may have preceded by a year or two. The Fourneyron and the Jonval were, for a long time, the only turbines used in Continental Europe. Meanwhile, the idea was exported to America, where Howd and Francis developed the forerunner of the mixed-flow turbine. This, in turn, was sent back to Germany and Europe took up the inward flow principle at about the time the development of the "Hercules" introduced a new period of wheel design in this country.

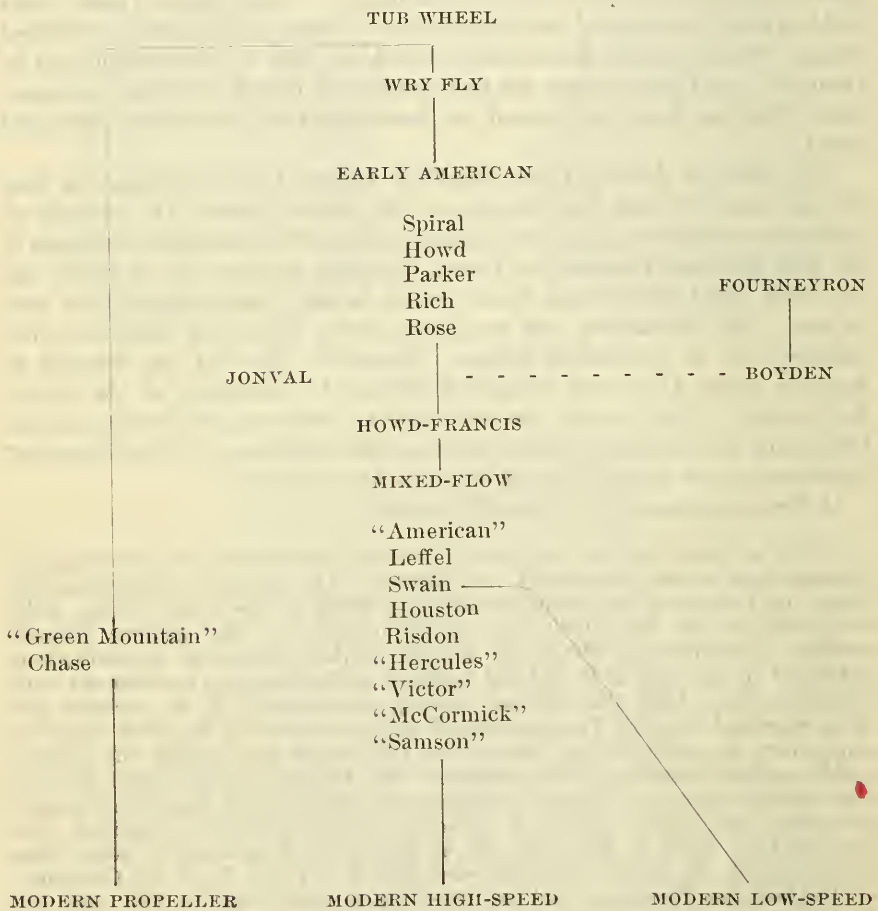
A Swiss engineer, Mr. A. Streiff,* states:

"It is a matter of fact that every marked improvement in the design of pressure-type wheels originated in America. The classic investigations by James B. Francis of his 'center-vent' water-wheel at the Boott Cotton Mills at Lowell in the year 1850, are the foundations of the modern Francis turbine. Professor F. Prasil, of Zürich, in his theoretical investigations published in the year 1905, did not hesitate to illustrate his conclusions with examples taken from the original Lowell experiments. It is, perhaps, not to be regretted that the Francis turbine was not reared in the same scientific atmosphere in which it was born, since this might have stifled the innumerable original creations of the inventors who followed. Each small foundry and machine-shop, so to speak, manufactured water-wheels based on Francis' principle, and hardly any new form of runner can be conceived that has not been made in the past, and is perhaps still running in some New England mill. It was not until the year 1875 that the J. M. Voith Company, of Heidenheim, Germany, took up the Francis wheel, and in 1876 that the Escher Wyss Company, of Zürich, Switzerland, followed suit".

Mr. Streiff further states that, in 1914, American practice in the construction of high-speed, low-head runners far surpassed the best that could be produced in Europe. Table 1 gives the characteristics of American water-wheels, for the period 1847-1900, on the basis of a 30-in. wheel.

* "Electrical Engineering and Hydro-Electric Development", *Transactions,* Inter. Eng. Cong., 1915, p. 498.

FAMILY TREE OF MIXED-FLOW TURBINE



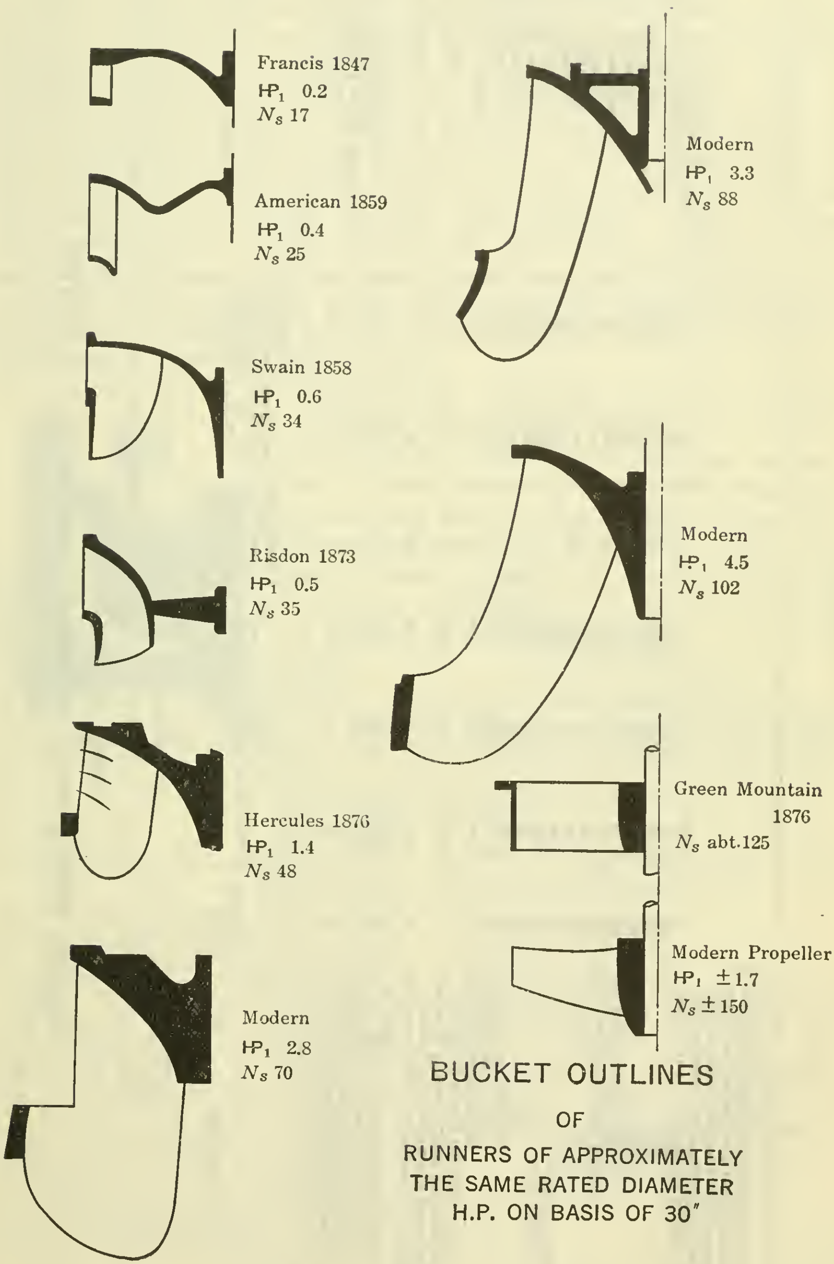

Francis 1847
HP_1 0.2
N_s 17
American 1859
HP_1 0.4
N_s 25
Swain 1858
HP_1 0.6
N_s 34
Risdon 1873
HP_1 0.5
N_s 35
Hercules 1876
HP_1 1.4
N_s 48
Modern
HP_1 2.8
N_s 70
Modern
HP_1 3.3
N_s 88
Modern
HP_1 4.5
N_s 102
Green Mountain 1876
N_s abt.125
Modern Propeller
HP_1 $\pm$1.7
N_s $\pm$150
BUCKET OUTLINES
OF
RUNNERS OF APPROXIMATELY
THE SAME RATED DIAMETER
H.P. ON BASIS OF 30″

Fig. 21.

TABLE 1.—CHARACTERISTICS OF AMERICAN WATER-WHEELS, 1847–1900, ON BASIS OF 30-INCH WHEEL.

Date.	Type.	1-Ft. Head. Revolutions per minute at maximum efficiency.	1-Ft. Head. Horse-power, maximum.	1-Ft. Head. Horse-power at maximum efficiency.	Efficiency. Full power.	Efficiency. Half power.	Efficiency. Maximum.	N_s (full power.)	Remarks.
1851	Boyden	38.3	0.47	....	79.4	46	79.4	26	Tremont turbine, inside diameter of 30 in.
1847	First Francis Model	44	0.19	....	....	....	71.6	19	2 13/16-in. bucket height; no gate.
1849	Boott-Francis	39	0.20	....	79.7	(55)	79.7	17	First Francis wheel installed.
1869	Swain	44	0.59	0.59	82.2	67.7	82.2	34	H. F. Mills, Lowell, 42-in. wheel; 5.35-in. buckets.
1870	Swain	45	0.69	0.69	81.9	....	81.9	37	do. Same model. Buckets. 7.4 in; lower band lowered; all else (except gate) the same.
1874	Swain	46	0.76	0.73	83.5	72.1	83.85	40	James B. Francis. Test on present Boott No. 2 on wheel shaft; no draft tube.
1872	"American"	38.5	0.41	0.33	76.8	72	80.4	25	Emerson at Holyoke.
1871	Leffel	43	0.48	....	74.3	(60)	74.3	30	Emerson at Lowell.
1873	Tyler Scroll	44	0.42	....	81.6	57	81.6	29	" " Holyoke
1873	Houston	44	0.52	....	88	54	88	32	" " "
1873	Risdon	49	0.51	....	90.5	73	90.5	35	" " " , with diffuser.
1873	Risdon	50	0.49	....	88.8	....	88.8	35	" " " , without diffuser.
1876	"Hercules"	40	1.44	1.29	83.8	73	89.2	48	" " "
1878	"Victor"	42	1.32	....	86.7	65	86.7	48	" " "
1883	"Hercules."	40	1.44	1.28	85.14	....	86.94	48	In present Holyoke Flume.
1897	"Samson"	51	1.85	1.71	82.03	75.6	84.30	69	Holyoke Test No. 979
1897	Special "Hercules"	40	1.79	....	84.0	70.5	84.0	55	" " " 1051
1897	"Victor"	42	1.80	1.72	80.59	68.8	81.07	56	" " " 1061
1899	Smith-McCormick	53	1.65	....	84.55	69.3	84.55	68	" " " 1201
1876	"Green Mountain" Propeller	126	0.98	....	....	....	(60)	125	Calculated from maker's tables; 10-ft. head readings taken for 28 and 32-in. wheels used and averaged; water and speed assumed to be correct; wheel efficiency assumed at 60% and horse-power calculated from this.

The Scroll Setting

Many of the early turbines, such as the Boyden and the Swain, were built integral with their flumes. With the appearance of the small turbine, various settings were evolved. In the most common the wheel was placed directly in a hole in the floor of the flume which in some cases was widened at the end to form a box-like structure. By 1870, many of the small wheels were set in cast-iron globe-shaped cases and supplied by a pipe; this was particularly common with the higher heads. As the size of the wheel increased, the cost of cast-iron casings became, in most cases, prohibitive. Many of these early settings were excellent hydraulically, and often were quite as good as could be designed. In later years, however, as wheels increased in size, sheet-iron cases began to be used. All knowledge of hydraulics apparently was thrown to the winds, and structural conditions determined the shape of the casing. The boiler-maker ruled.

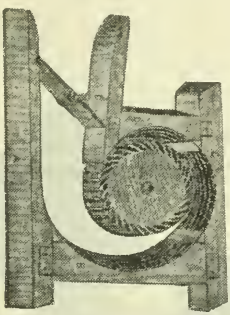


Fig. 22.—Rick Scroll, 1848.

Many of the early wheels were set in wooden scroll cases (Fig. 22) and had no guides. Fig. 23 shows a type of wheel quite common for many years. It was used much in saw-mills as an auxiliary wheel for running back the log carriage. This diagram was copied from a drawing found among some of Boyden's papers, in the files of the Amoskeag Manufacturing Company, of Manchester, N. H. The construction of a similar wheel is described by Craik.*

After 1850, many scroll wheels came into use. They usually were of iron and were entirely self-contained, that is, the scroll was built integral with

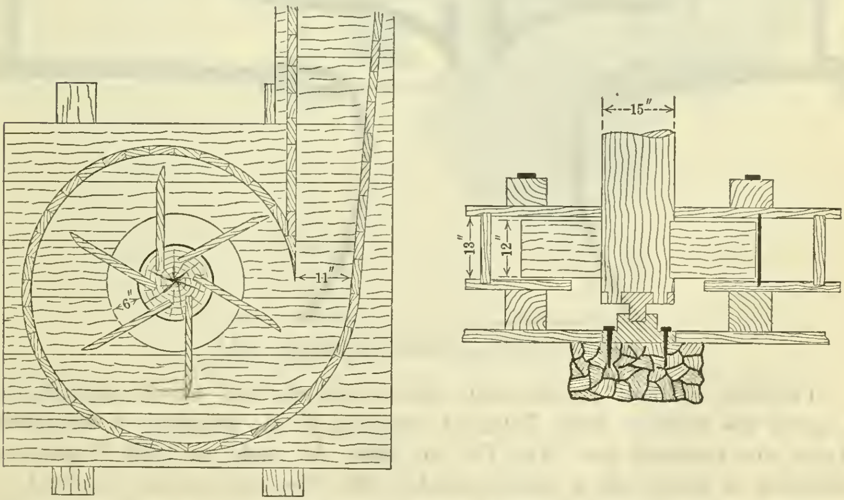


Fig. 23.—Wooden Center Vent Wheel.

* "The Practical American Millwright and Miller", p. 205, Phila., 1870.

the bearings which supported the runner. (Fig. 24.) The gate was usually a plain sliding rabbit-trap, at the entrance to the scroll, although a butterfly was also used. These wheels had no guides, and were very poor at part gate, although at full gate they gave an efficiency of about 70 per cent.

Fig. 25 shows a model of a scroll wheel patented by Daniel T. Lakin, of Hancock, N. H., in October, 1863. Its runner was of the true Howd-Francis type, with flat blades, and was inverted so that it discharged upward. The interesting feature of this wheel was the regulating mechanism which was a register gate, fitted inside the runner and revolved with it. Closing the gate reduced the discharge area of the buckets and decreased the flow. Directly attached to the shaft are the flyballs which actuate the gate. The whole regulating mechanism is part of the runner and shaft, and the entire wheel is self-contained. There is no question but that such an arrangement would give poor part-gate efficiencies, due to contraction losses through the gate, but it is most interesting as an early example of the present practice of placing the flyballs directly on the shaft of a vertical unit.

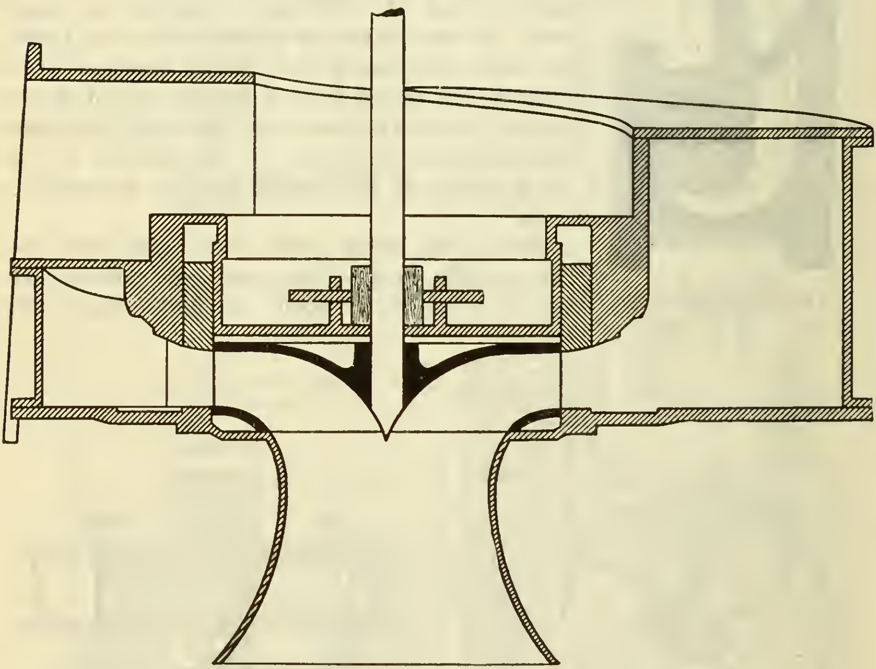


Fig. 24.—Scroll Wheel by Boyden, 1854.

Probably the best of the scroll wheels, and the one which survived the longest, was made by John Tyler, of Lebanon, N. H., grandson of Benjamin Tyler who patented the "Wry Fly" in 1804. As made, in 1873, it gave an efficiency of 81.6% and a specific speed of 29. The same runner, placed in a register-gate flume casing, gave a lower efficiency than when used in the scroll. A scroll was sometimes divided into two compartments by a thin horizontal

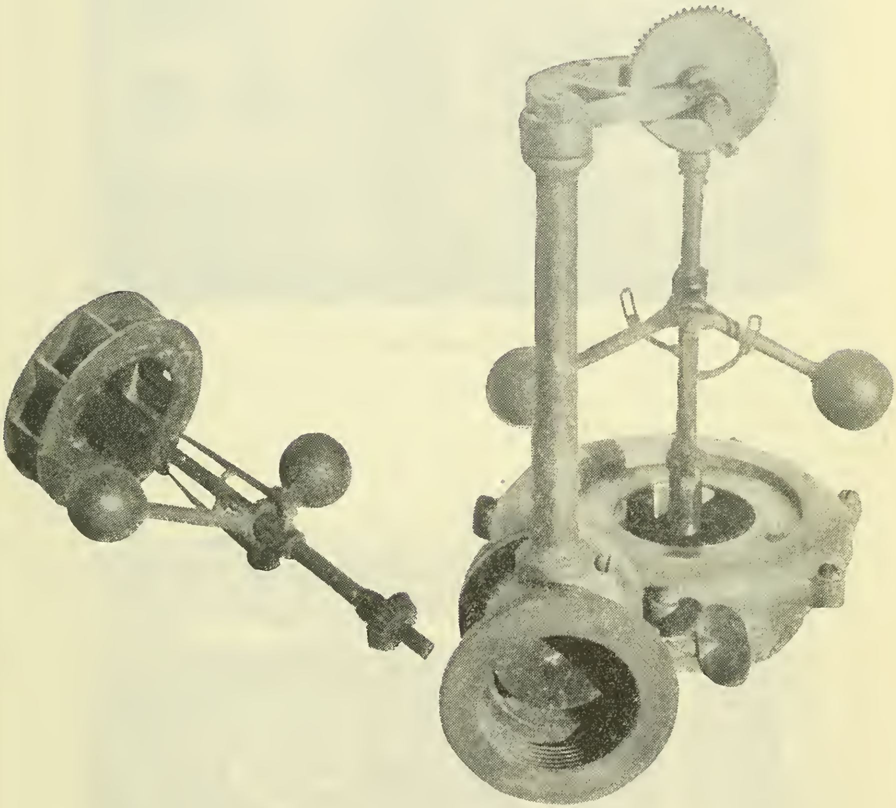


FIG. 25.—LAKIN WHEEL, 1863.

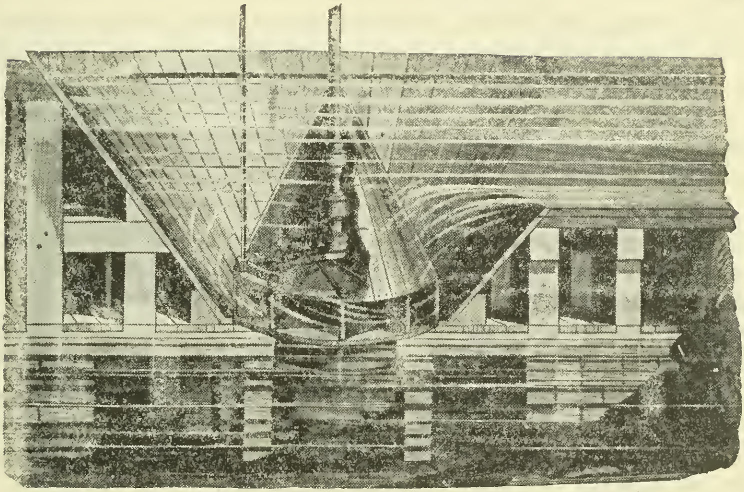


FIG. 26.—DROUILLARD FLUME, 1880.

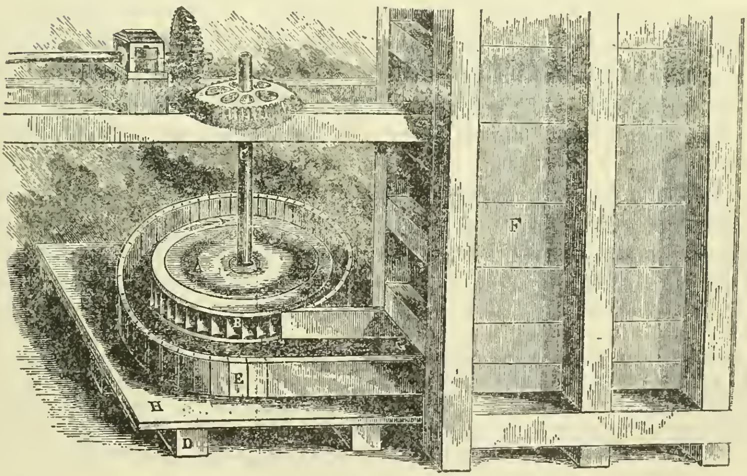


FIG. 27.—WARREN SCROLL, 1860.

diaphragm, so that, with the gate partly shut, the same velocity and direction of water might be retained in the lower half of the scroll. During the "cut and try" period, the iron scroll casing was used by many makers, especially with smaller wheels, but by about 1880 they all had disappeared with the exception of a few, such as the Chase which, however, was not a true scroll wheel. The Drouillard flume (Fig. 26) was an attempt to improve the open-flume type of setting.

The time had now come in which, the increasing size of the wheels rendering the cast-iron case prohibitive in cost to most makers, and a setting more permanent than the wooden flume being desired, wheel casings of sheet iron came into use. About this time, the use of the draft-tube enabled the wheels to be placed above the tail-water, where they were more easily accessible for inspection and repair. For many years, almost every wheel maker considered the draft-tube merely as a device by which the wheel could be raised clear of the water and yet the full head be retained, and it appears that only one maker, Risdon and Company, appreciated its value in regaining velocity head. The development of the draft-tube will be discussed later.

With the coming of the boiler-maker period, the scroll setting disappeared, and it seems to have been almost entirely forgotten. Indeed one wheel maker of the present day is somewhat surprised that "examples have been found in what is left of some early mills in Connecticut of turbines of primitive construction, equipped with a volute form of water passage surrounding the runner".

Not only was the scroll used largely during the early years of the development of the American turbine, but its principle also was studied and understood. An article* by A. G. Hillberg, on scroll design, described a method of dividing the water used by the wheel, into a number of imaginary lines of flow, and of carrying these back through the scroll, thus studying the effects of shape. In the files of the Proprietors of Locks and Canals, there is a study, presumably by Francis, dated 1857, of a scroll design for the grist-mill wheel in which this same method is used.

The American Water Wheel Company, of Wareham, Mass., makers of the Warren wheel, were early users of the scroll case. (Fig. 27.) In a letter to the Committee of the Ninth Exhibition of the Massachusetts Charitable Mechanics Association, dated September 17th, 1860, that Company discusses its theory of scroll design. A few quotations are given, as follows:

"Our improved scroll is formed upon a plan which enables the water to pass, at the periphery of the wheel, at an uniform velocity at all parts of the wheel's circumference. The water in the scroll passes (or should pass) towards the center of the wheel with an accelerated velocity in proportion to the diminution of the area of the circles over which it passes."

The circles mentioned are a series of concentric circles, of area ratios of 1 : 2 : 3, etc., used in the construction of the scroll by graphic methods. This means that the water is given a uniform centripetal acceleration for each unit of angular distance traversed.

* *Engineering Record,* October 3d, 1916.

"The principle of the centripetal action of the water in the scroll is the same as that of the vortex, or whirl-pool, accelerating the velocity of the water in proportion to the diminution of the area as it approaches the center".

After being abandoned in the United States, the scroll was taken up by the Germans, and largely used for high-head Francis runners. Pfarr credits Voith with being the first to build an iron, spiral-cased, wicket-gate turbine (1894).* This type of wheel was much used in German and Swiss practice, and when high-head developments began in this country it was brought back from abroad. The first hydro-electric station at Niagara Falls was equipped with Fourneyron turbines made in the United States after designs by Faesch and Piccard, of Geneva, Switzerland. It is interesting to know, however, that the first turbines running under the full fall at Niagara were built by an American firm, James Leffel and Company, after the designs of A. F. Sparks.

In the earlier years of high-head development, the scroll was sometimes used, but a great many installations were of the boiler-maker type. By about 1904, however, the spiral casing was in general use for high-head wheels.

In 1903, a vertical unit with a spiral, steel-plate scroll was placed in a plant on the River Glommen at Kykkelsrud Falls in Norway, under a head of about 60 ft.† This appears to have been the first example, on a large scale, of what is now the best modern practice.

Until reinforced concrete made the modern setting possible, wood and cast or plate iron were all that could be used, aside from masonry. Metal cases were used, but, for a big unit, a plate scroll would have been considerable of an undertaking. It was much easier to build some kind of a plate casing, usually circular in form, around the wheel and to let it go at that. Efficiency was not sought as it is to-day, and in the days of direct drive and small units, a few per cent did not mean very much. With the appearance of central stations and large units, even 1% meant money, and over-all efficiency was considered as it never had been before. By about 1900, and for a considerable time thereafter, a majority of the plants had horizontal shaft units, which either drove generators or were direct-connected to machinery. Electrification called for a fairly high speed, and this was accomplished by using batteries of runners of small diameter. Until the high-speed wheel was developed further, no other alternative was possible, as long as high speed was required.

The need for high speeds developed the runner and resulted in specific speeds of almost double those of the early wheels, such as the "Hercules" and "Victor". Because of this, it soon became possible, even with low heads, to drive large hydro-electric units by a single runner. Three elements—the development of the runner, the need for high efficiency, and the growth of the use of reinforced concrete—made possible the modern vertical unit, which appeared in this country about 1912. The first plans for Keokuk, Iowa, were for double-runner vertical units.‡ At present, the single vertical runner is used almost entirely for all low-head developments, and even high-head Francis runners have recently been placed in vertical cast-iron spiral settings, such

* "Turbinen für Wasserkraftbetrieb," Atlas, Plate XXVII, Berlin, 1907.

† Koester, "Hydroelectric Developments and Engineering", p. 382, N. Y., 1909.

‡ *Engineering News*, September 28th, 1911.

as the Big Creek No. 8, 680-ft. development of the Southern California Edison Company. Fig. 28 shows an installation of 58-in. wheels operating under a head of about 37 ft., at the Gardner's Falls plant of the Greenfield (Mass.) Electric Light and Power Company. This plant was built in 1913, and the acceptance test showed a wheel efficiency of more than 94 per cent.

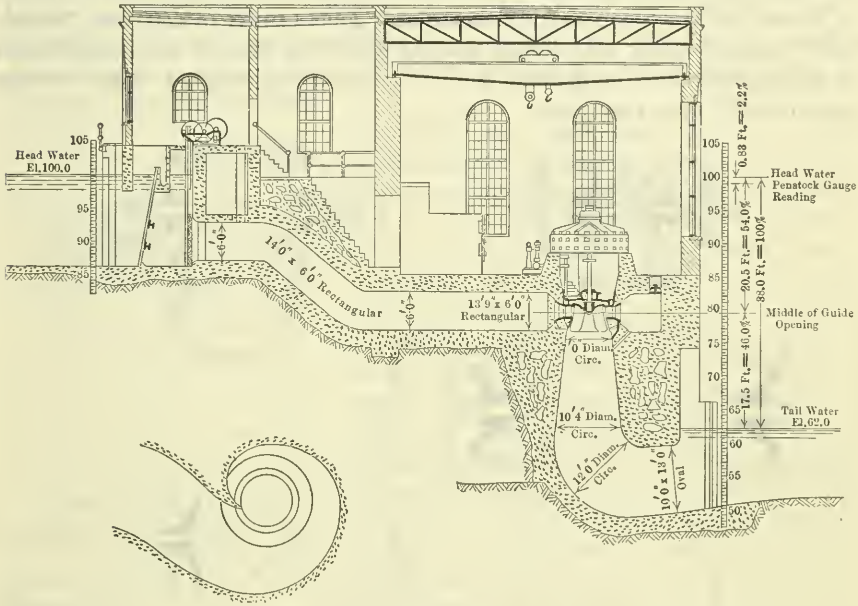


Fig. 28.

The Horizontal Wheel and Its Setting

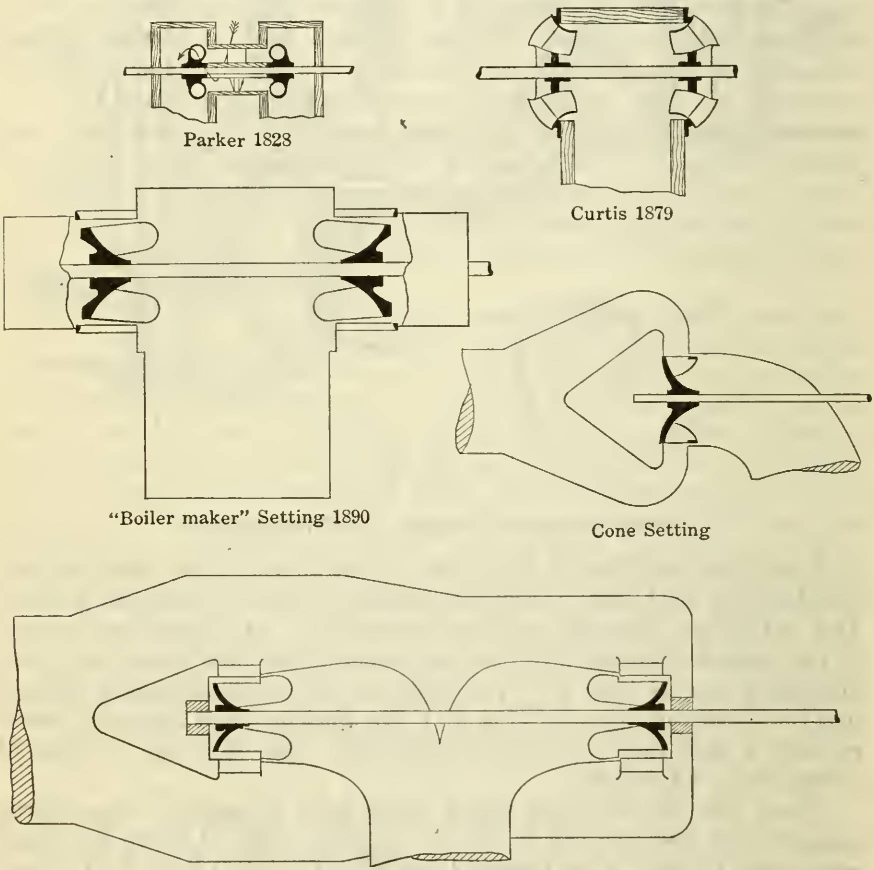
During the early days of the turbine, it was a natural step from the horizontal shaft of the breast-wheel to the placing of turbines in the same position. This setting was commonly used until about 1850. The wheels were usually of the outward discharge type, such as the spiral and Rose wheels, and often discharged into the open air. The double Parker wheel discharged outward into two wooden draft-boxes. (Fig. 29.) The efficient use of horizontal wheels required a draft-tube and until the draft-tube came into use this type of setting was not practical.

About 1880 the horizontal setting began again to appear. Gates Curtis seems to have been the first to use it. In 1879, a pair of Curtis horizontal wheels were installed in the Hudson River Mill at Palmer's Falls, N. Y. They were placed directly on the horizontal machine shaft, 16 ft. above the tail-race. A square wooden draft-tube was used and the head-water stood 12 ft. above the center line of the wheels. In a letter to the wheel maker, Mr. Curtis states:

"We are satisfied by experiments made with pipes leading from the top and other parts of the draft tube attached to glass and mercury gauges that we get equal results from the wheels, as we would were they placed at the

level of the tail-water. This arrangement of taking off power so far above the tail-water, thereby avoiding the annoyance and expense of bevel gearing, is proving most satisfactory in many ways * * *."

A pair of horizontal Curtis wheels (Fig. 29) were tested at Holyoke in 1879, and found to give an efficiency of 72%, whereas, on a vertical shaft, one alone gave 83.6 per cent. About 1882, the Humphrey Machine Company, of Keene, N. H., began to build horizontal double units in cast-iron "camel-back" cases of rather fair design, and, by 1890, this type of unit, constructed of boiler-plate, was in general use. The great majority of these settings hydraulically were very poor.



Modern Horizontal Setting

Fig. 29.

Some double horizontal settings were made of cast iron, such as the Risdon wheels in the Jefferson Mills of the Amoskeag Company of Manchester, N. H., J. B. Francis, Consulting Engineer, but they were much the exception to the rule. These wheels were interesting because on one shaft were runners operating under two different heads. There were other good horizontal settings,

such as that of the Lawrence Company of Lowell, placed in 1895 (Fig. 30), but they were not common.

In many of the horizontal units built in later years, the casing was a continuation of the penstock, and the water approached the wheels parallel to the shaft. Such a setting, with a correctly designed casing, was a great improvement over the earlier ones in which the water entered a cramped casing with sharp corners, at right angles to the wheel shaft. Fortunately, however, increase in runner speeds and the use of reinforced concrete permitted the beginning of a new period in wheel settings and the rule of the boiler-maker is now a thing of the past.

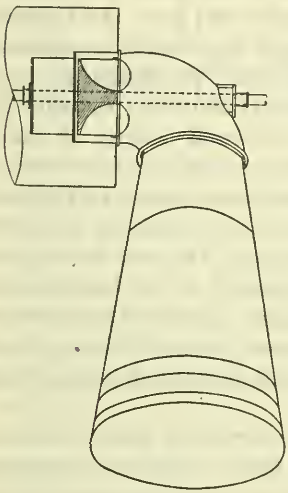


Fig. 30.

Probably the worst examples of horizontal wheels appeared during the Nineties. (Fig. 29.) The setting usually consisted of either a rectangular box or a tube. The wheels were placed at each end, and discharged toward each other. A round metal draft-tube extended from the bottom of the draft-box into the tail-water. Every opportunity for eddies and whirls was offered by the draft-box and tube, and sharp edges and corners abounded everywhere. The worst part of this type of setting was that the water was not conducted smoothly to the draft-tube. It was discharged at a fairly high velocity into a large box where it swirled around and was allowed to find its way out through the hole in the bottom of the casing. Sometimes each wheel had its own quarter turn and draft-tube and was set in a common casing, but, usually, both discharged into the same tube. One wheel catalogue shows an ordinary double horizontal setting, to which had been added a third unit with a vertical shaft. This unit discharged downward and was placed directly above and concentric with the draft-tube opening.

Perhaps the worst feature of the earlier horizontal wheels was the proximity of the runners, when both discharged inward against each other. In some cases the distance from the bottom of one runner to the other was as small as one wheel diameter. In the early days of the boiler-maker period this distance was usually from 1.5 to 2 runner diameters. In 1894, at the plant of the Appleton Company of Lowell, a test on Rodney Hunt wheels showed that insufficient distance between runners reduced the efficiency 10 per cent. A pair of 30-in. "Hercules" wheels were tested for the Middlesex Company of Lowell in 1896. As tried at first, the runners were 2.26 diameters apart. By increasing this distance, 16 in., or to 2.8 diameters, the maximum efficiency was increased 4.7 per cent. Modern runners, operating under medium to low heads, should be spaced from 3 to 4 diameters apart.

The "camel-back" type of cast-iron draft-chest was gradually evolved, and showed a great hydraulic improvement. The discharges of the two wheels, instead of being directly toward each other into an open case, were gradually

turned downward by a curving partition wall so that they were flowing in a more or less parallel direction when they met. Swain devised the idea of carrying this dividing partition all the way down, thus, in effect, giving each wheel a separate draft-tube. Fig. 29 shows the cone setting for a single horizontal wheel. This excellent design for small units under fairly high heads was used by several makers.

The double horizontal wheel in a cast-iron, "camel-back" draft-chest, when placed in a casing of good design and fitted with a properly flaring draft-tube, was an excellent prime mover. The best practice usually was to place this wheel in a casing that was a continuation of the penstock, so that the flow was parallel to the wheel-shaft. The approach to the wheel was eased by placing a cone-shaped casing over the up-stream end of the unit. In a setting of this kind, the water passage around the first wheel was sometimes cramped, and the flow to the down-stream wheel was restricted. To obviate any possibility of this, the casing was sometimes enlarged at the point opposite the gates of the up-stream wheel. (Fig. 29.) A horizontal setting of Smith wheels in a casing of this kind was placed at the plant of the International Paper Company, at Glens Falls, N. Y. These wheels were tested in 1918 and showed an efficiency of 88%, which is thought to be the highest authentic result ever obtained from a double horizontal setting. The best results that can be obtained from such a unit will always be from 2 to 4% less than the efficiency obtained from one of the runners tested, on a vertical shaft, under the best conditions. There are some places, however, where efficiency is not the primary requisite, and certain advantages of the horizontal setting make it suitable.

The horizontal setting, to a very large extent, is passing away, but there are still certain cases to which it is pre-eminently fitted. The most important of these is found in pulp mills, where the wheels are direct-connected to the horizontal shaft of a battery of grinders. Conditions call for a fairly high speed, regardless of the available head and the multi-runner unit is often the best adapted to the need.

The Draft-Tube

In June, 1840, Zebulon and Austin Parker, of Licking County, Ohio, were granted a patent for a "Draft-Tube for Water-Wheels". Parker wheels, usually, if not always, were set in pairs on a horizontal shaft, fed by a crude scroll case, and each discharged outward into its own draft-tube which was merely a long rectangular wooden box. The object of this setting was not to gain efficiency, but to allow the wheels to be placed above tail-water. The French Jonval-Koechlin turbine, in 1841, was equipped with a draft-tube, but the Parkers seem to have been the first to apply it.

The first example of the use of a draft-tube to regain velocity head was the "diffuser" of Boyden (Fig. 31), which, by 1846 was being applied to most of the Boyden wheels built. It was shown to add about 3% to the wheel efficiency, by regaining the velocity head of the discharged water. Theoretically, it should have saved almost 5%, so the diffuser efficiency was about 60 per

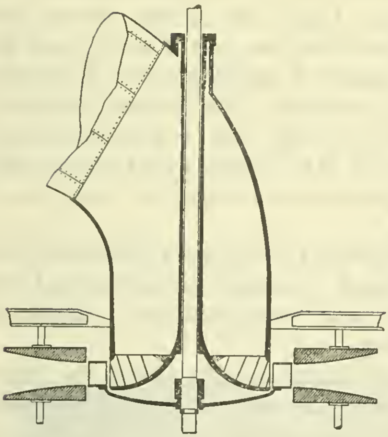


FIG. 31. BOYDEN WHEEL AND DIFFUSER.

cent. The flare of the parallel disks was apparently too sudden, and the water failed to cling to the sides of the diffuser, with the result that the discharge was a succession of surges. In later years, Boyden wheels were not equipped with diffusers, probably because their great size required unnecessarily large wheel-pits which, in many cases, might have required the changing of the foundations of the mill. Only one diffuser is left in Lowell at the present time; it is on the 1853 Boyden wheel at the plant of the Merrimack Manufacturing Company.

The draft-tube, as a diffuser, does not appear again for many years. By 1870, many wheels were set above tail-water on wooden stave or sheet metal tubes. Sometimes the construction of the hooped wooden tubes required a slight flare, but they usually were straight. The design, if there was any, was usually based on the velocity with which a bubble of air would rise in water. In 1881, Gates Curtis, maker of the Curtis wheel, recommended the proportioning of draft-tubes for a velocity of from 5 to 8 ft. per sec. The general feeling among wheel makers was that a wheel could be used with a draft-tube with little or no loss in efficiency, provided the tube was air-tight.

About 1880, James Emerson made a series of experiments on draft-tubes, using a 15-in. Victor wheel. He began with a draft-tube the inside diameter of which was the same as the wheel skirt, and then, by inserting fillers, reduced the area by degrees. The velocities in the tube varied from about 5.5 to 12 ft. per sec., with the best efficiency at the lower velocity, and this efficiency was considerably less than that obtained when the wheel was tested without a draft-tube. The draft-tubes used were all straight sided, and were from about 7 to 10 ft. long.

At Holyoke, in 1873, the Risdon Company tested a 36-in. wheel which gave an efficiency of 90.5% with a draft-tube diffuser and 88.8% without it. This trial must have convinced the Risdon Company of the efficacy of the appliance, for it built draft-tubes of excellent design during the period when other makers were evolving weird affairs out of boiler-plate.

The Risdon runner discharged axially over an annular section, so that there was a dead area around the center of the wheel. To eliminate this, an inverted cone was fitted below the runner, so that the discharge passage was smoothed. The draft-tube, which was slightly flared and usually of cast iron, was excellent and far ahead of its contemporaries. It was claimed that the efficiency of the wheel was increased 2% by the use of the diffuser. However, during the period of the double horizontal unit, even the Risdon draft-tubes fell down, and examples are found of two wheels discharging against each other in a cramped wooden draft-chest.

In the days of direct drive, a difference of 2 or 3% in wheel efficiency did not mean a great deal. The wheels were of such low specific speeds, that the total gain realized by the use of a draft-tube was only 2 or 3%, and the gain, in many cases, did not justify the expense of building a good draft-tube. It is interesting to note that "W. W. T.", writing of the "Green Mountain" propeller wheel, realized that, with a wheel of this type, a draft-tube would be of greatly increased value. He says: If Mr. Boyden would put his diffuser on one of these wheels, we would promise him a gain of more than 3 per cent. It would be more nearly 50".*

It would appear that during the period from 1870 to about 1900, or a little later, the use of the draft-tube, as a diffuser, was generally understood, but it was not generally used. The dollars and cents value of a draft-tube usually did not justify the necessary outlay.

With the coming of electrification and higher specific speeds, the draft-tube became of greater potential value, and the use of reinforced concrete made it a simple matter to build a tube of any desired shape. The development of large central power stations meant that even 1%, when translated into kilowatt-hours per year, amounted to a considerable sum. The draft-tube was more than justified economically, and its use, as a diffuser, became universal.

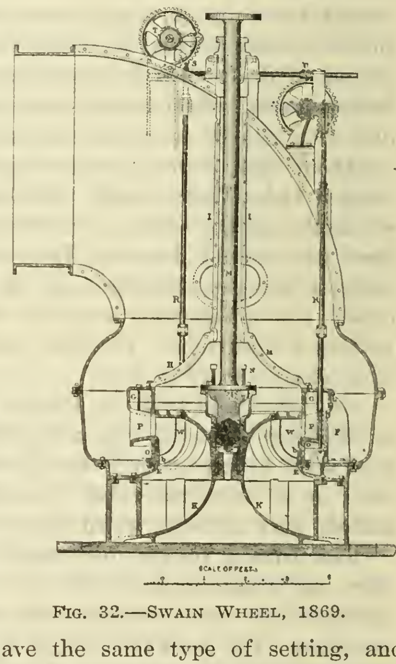


Fig. 32.—Swain Wheel, 1869.

Apparently, the pendulum has swung to the other extreme, and there are now on the market various kinds of patent draft-tubes, each of which, like the old patent medicines, is promised to be the cure-all for every hydraulic trouble. The basis of one of these types is an inverted cone placed beneath the discharge opening of the draft-tube, with its axis coincident with that of the runner. The object is to change smoothly and without shock the direction of the water from a vertical to a horizontal direction.

The placing of a cone beneath the draft-tube is almost as old as the turbine itself. Some of the early Jonval-Koechlin turbines had it. Almost every German textbook on water-wheels from 1860 to Dr. Camerer's "Wasserkraftmaschinen", of 1914, shows one or more settings with cones below the draft-tube. English and French textbooks have the same type of setting, and Beardsley shows one.† The Swain wheel had a lower step bearing, and, by 1869, this had been smoothed off to form a cone (Fig. 32). Fig. 33 shows a Swain wheel, placed in 1875, at the Boott Cotton Mills, Lowell, Mass. To

* *Emerson's Turbine Reporter*, January, 1876.

† "Hydro-Electric Plants", p. 344. N. Y., 1907.

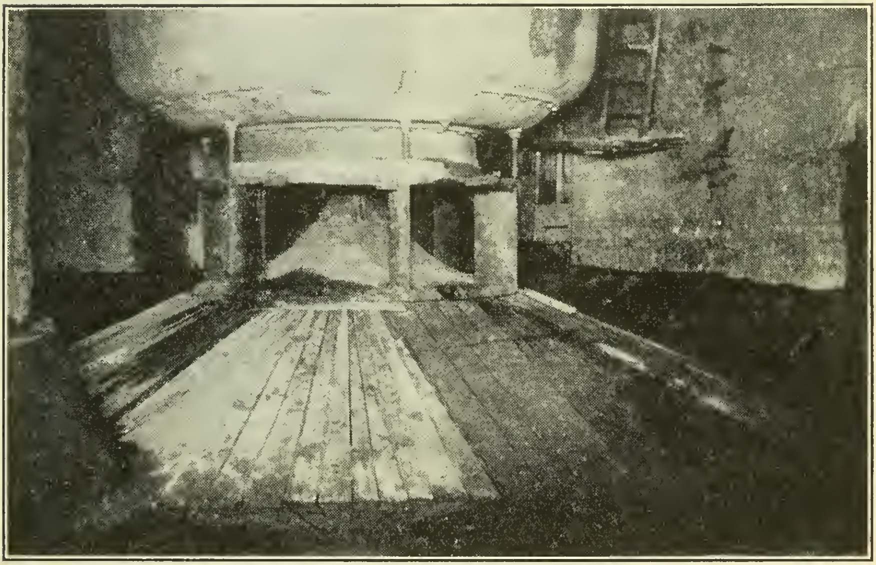


FIG. 33.—SWAIN WHEEL AT BOOTT COTTON MILLS.

better conditions, the cone was continued, as shown, by wooden planks, and, in another instance, at the plant of the Hamilton Manufacturing Company of the same city, it is made of concrete. The iron-cased Burnham wheels of about 1890, had a metal cone below the runner.

Fig. 34 shows a wheel setting erected by the T. H. Risdon Company at the Lawrence Woolen Company, Lawrence, Mass., in 1883. In the maker's catalogue (undated), of about this period, it is stated:

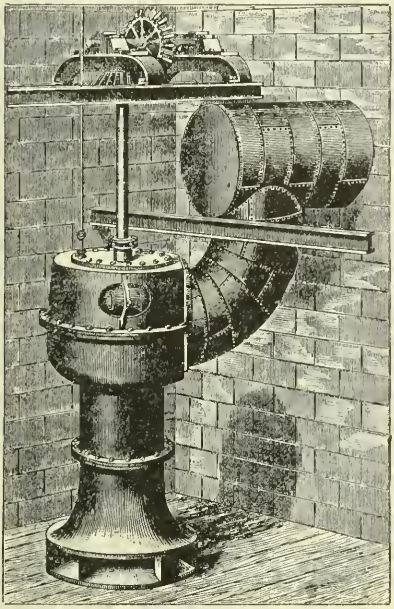


Fig. 34.—Risdon Diffuser.

"This wheel and the two preceding it have diffusers. In the Lawrence Woolen Company, a very shallow pit was already constructed, in which the water only stood about 18-in. deep. If the end of the draft-tube had been set low and had discharged the water vertically, as in the preceding wheels, it could not have escaped freely, and there would have been a corresponding loss of head. Hence, the upper part of the tube was constructed as in the previous case, but the lower end has an outward discharge. We have carefully constructed diffusers, both with downward and outward discharges, and to obtain clear evidence of what the gain was, have tried the same wheel, both with and without a diffuser, and in every case have found a gain.

"The increased economy of water obtained by a diffuser is 2 per cent. When the water leaves the water-wheel, it is traveling with a rapid velocity of about 3% of that due the whole fall. Of this loss, 2% may be saved by a diffuser. If the wheel has 200 h. p., 4 h. p. would be saved, and, if it must be made up by steam, there would be a saving of about $200 the first year, which would more than pay for the diffuser.

"Hence, where great economy of water is desired, a diffuser is a good investment. Every year we make more of them than in previous years. This arrangement here shown is the best possible for many locations, and, under such circumstances, we prefer a diffuser to any other arrangement. We always build the diffuser of cast-iron, believing that the only way to obtain a satisfactory arrangement."

Water-Wheel Testing

The question has arisen, at various times, as to the accuracy of results obtained at the present Holyoke Testing Flume. Before discussing this matter, a rough survey will be made of all the large-scale turbine tests of record. Such tests as those made by Francis, on the Tremont turbine (Boyden), the Boott center-vent, the Boott Swain, and the Tremont and Suffolk Humphrey are above suspicion. They were carried out under scientific conditions, with practically no regard for expense, by the most eminent hydraulic engineer in the United States, if not in the world. The test of a 42-in. Swain wheel,

at Lowell, by Mills, in 1869, has been questioned by James Emerson, but unjustly it would appear, and without good reason.

In 1859-60, the City of Philadelphia conducted a series of tests at the Fairmount Water-Works. They are understood to have been rather crude, and the results are not considered trustworthy. Instead of using a Prony brake for the measurement of power, a method was used whereby the wheel hoisted a given weight. The wheels tested were Jonvals and early scroll wheels; a Jonval built by Stevenson gave the best results.

The wheel tests at the Centennial Exhibition in 1876 were tested under the direction of Samuel Webber. The highest results were given by the Risdon wheel. The following is quoted from Mr. Webber's discussion of the paper by the late R. H. Thurston, M. Am. Soc. C. E., on "The Systematic Testing of Turbine Water-Wheels in the United States", before the American Society of Mechanical Engineers:*

"There have been some remarkable tests reported from the Old Flume [Emerson's], which it has been impossible to repeat or duplicate at a later date with the same wheels, and the 90% test of the Risdon wheel, referred to by Professor Thurston, is one of them. I have no doubt of the correctness of the Centennial test, which gave 87.68% net effect from this wheel, for other wheels tested by other engineers, in various places, corroborate it very closely, but I have never myself got so high a result from any other wheel; and it should also be noted that the very high efficiency reported from some wheels has been usually found in the tests of very small wheels, of 15 or 20-in. diameter, where a very considerable effect might be exercised upon the wheel by the man who handled the lever at the brake."

In the same discussion, another view is given as to the accuracy of the 1876 tests, as stated by the late Charles E. Emery, M. Am. Soc. C. E. After describing how petty politics resulted in the appointment of Mr. Webber, he says:

"As the only object was to obtain reliable and creditable results, the writer undertook to co-operate with Mr. Webber in the conduct of the work. This, however, did not prove an easy task, as Mr. Webber had made a great many tests, had acquired certain methods of his own, and did not care to go into many of the refinements which such an opportunity would have made of great scientific value. While he was pleased with the action of the Judges, he evidently felt, moreover, that his authority was from another source, and insisted practically on having his own way, and under the circumstances little else could be done. The original design was such that the water was necessarily admitted to the weir approach at the side, so that, although ample provision had been made in the length of the approach, the current on the side opposite the inlet was very much the stronger. The speaker suggested a series of baffling screens or racks, such as are described in Mr. Francis' work, and finally a single one was hastily applied, but with the spaces between the bars so wide that there was still ample area for the water with greater velocity to pass along the side where it did before. Any further improvements were, however, considered unnecessary by Mr. Webber, and the experiments were conducted with the water approaching the weir at very different velocities on the two sides; and, moreover, on account of the recoil of the current from

* *Transactions*, Am. Soc. Mech. Engrs., Vol. VIII (1887), p. 359.

one side of the approach, floating bits of wood showed that all of the water did not approach the weir at a right angle, and the evidence of this deflected current was sufficiently marked to show a ridge in the crest of the fall at the weir itself."

James Emerson was a most interesting and outstanding character during the closing years of the "cut and try" period. He had been a sailor at one time, but soon after the close of the Civil War, he became interested in the testing of water-wheels. He was associated with early wheel tests at Lowell in 1869-71, and afterward moved to Holyoke, where he opened a commercial flume for the testing of wheels. The business prospered and many wheels were tested during the Seventies. A number of years were required to bring all the makers to a belief in the flume test, but Emerson's efforts were finally successful, as is shown by the prestige of the Holyoke test at the present day. James Emerson deserves the credit for the early development of the testing system, which was as necessary to the development of the reaction wheel as the "cut and try" period. One without the other would have been useless, but the combination of the two was what produced the "Hercules", the "Victor", the "McCormick", and the "Samson" turbines.

Emerson was a man of decided ideas and strong prejudices. His attitude, unfortunately, was that, if a maker did not have sufficient faith in his wheel to have it tested at Holyoke, which incidentally meant money in Emerson's pocket, the wheel was beneath his notice, and, as far as he was concerned, did not exist. Most of the wheels of the period, however, did go to his flume, and thanks to him, there is a rather complete list of tests on early American wheels. The absolute accuracy of his tests might well be questioned, but, comparatively, they must have been correct within 2 or 3 per cent.

Emerson was of extreme iconoclastic tendencies, and no institution in existence seemed to have escaped his abuse at some time or other. His most unusual book, "Hydraulics, Dynamics, etc",* treats of everything from technical matter concerning water-wheels to notes on the Bible, theology, law, woman suffrage, and spiritualism. He did much to educate the public by his annual reports and by his monthly magazine, *The Turbine Reporter*. Whatever were his bad points, his name is closely linked with the history of the development of the American mixed-flow turbine.

Emerson's testing flume was taken over by the Holyoke Water Power Company and, a little later, in 1881, the present testing flume was built under the direction of Clemens Herschel. The standards of the Holyoke test, from this time on, were the same as they are to-day. Concerning the accuracy of Emerson's tests, Mr. Herschel states:

"So far as I know, the Emerson tests are reliable, with the exception of some that must needs have failed, due to the routine, or mechanical, that is, hasty and perfunctory, manner in which they were in the course of time all conducted".

Since the arrangement of the present Holyoke flume is well known and has been described by many writers, it will not be necessary to describe it in detail. The water is measured by a sharp crested weir with which little fault

* Willimansett, Mass., 1894.

can be found. The power is measured with a dynamometer of the Emerson type, consisting of a broad-faced cast-iron pulley, with a wood-lined metallic brake band, cooled by a constant flow of water. Several sizes of dynamometers are used, depending on the size of the wheel. With a heavy load, the brake seems likely to stick and work unevenly at the lower speeds. It is thought that a considerable improvement might result from the use of an Alden absorption dynamometer. The late Professor Thurston stated* that the limit of error at Emerson's flume was from 3 to 5%, and that:

"A careful examination * * * has led the writer to the conclusion that the Holyoke Testing Flume, and the methods of observation and calculation employed there, are capable of giving the efficiencies of turbines tested correctly within a limit of error of certainly less than one per cent, and probably to within one-half of one per cent. For all practical purposes, the results of the trials of turbine water-wheels, at the Holyoke flume, may be taken as exact, and absolutely trustworthy."

In conclusion, it is only fair to state that, although all available sources that gave promise of any useful information have been consulted, there may be a few omissions. An historical study is no better than the sources consulted, and, in the present case, the sources were, for the most part, scant and scattered.

Many thanks are due to Mr. S. S. Kent, Assistant Engineer, The Proprietors of the Locks and Canals, for his help in preparing this paper.

* "Systematic Testing of Water-Wheels", *Transactions*, Am. Soc. Mech. Engrs., Vol. VIII, p. 49.

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PAPERS AND DISCUSSIONS

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THE RECONSTRUCTION OF THE BALTIMORE AND OHIO RAILROAD BRIDGE CROSSING THE ALLEGHENY RIVER, AT PITTSBURGH, PENNSYLVANIA

By Philip George Lang, Jr.,* M. Am. Soc. C. E.

Synopsis

This paper describes the reconstruction of the bridge of the Baltimore and Ohio Railroad Company, across the Allegheny River on the line of 33d Street, Pittsburgh, Pa.

Although the new structure which replaces a bridge built in 1884 at the same location, is not of unusual size, the necessity of maintaining uninterrupted railroad operation during the work, the requirement of the War Department that no interference with river traffic be occasioned, and local right-of-way conditions which restricted to narrow limits the available working space, render the reconstruction a matter of interest.

On September 1st, 1920, a 265-ft., double-track, through, riveted truss span, was rolled to permanent line at the old or low level, and, on December 20th, 1920, was jacked a vertical distance of approximately 15 ft., to a new high level, on which date, also, a 436 ft. 9-in., through truss span was rolled to permanent line at the new grade.

The bridge of the Pennsylvania System, crossing the Allegheny River on the line of 11th Street, was raised on February 22d, 1919, therefore, the Baltimore and Ohio Railroad Company's structure is the second to be elevated in accordance with the order of the War Department, requiring the raising of all bridges crossing the Allegheny River in the Pittsburgh District, and is the first reconstruction work completed under that order. This work has earned the commendation of the War Department, and the elimination of a dangerous grade crossing has received the favorable recognition of the local authorities.

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Engr. of Bridges, Baltimore & Ohio R. R., Baltimore, Md.

Historical

The Baltimore and Ohio Railroad enters Pittsburgh from the east and follows the north bank of the Monongahela River to the Smithfield Street Passenger Station. Through train movement for points west of Pittsburgh is by way of Laughlin Junction, across the city in a general northwesterly direction. The location of the Baltimore and Ohio Railroad within the Pittsburgh area is shown on Fig. 1.

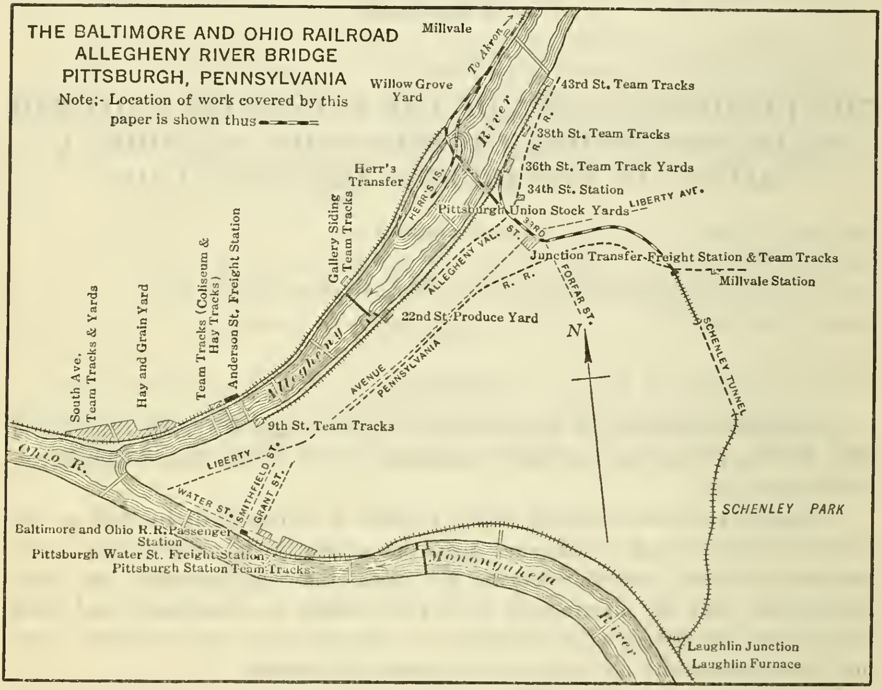

Fig. 1.

That part of the line from Laughlin Junction to Willow Grove is known as the Pittsburgh Junction Railroad and embraces what were originally parts of the contemplated trackage of two incorporations, namely, the Pittsburgh Local Railroad Company and the Pittsburgh Junction Railroad Company. As the Allegheny River Bridge played an important part in the development of the Baltimore and Ohio Railroad in and about Pittsburgh, a brief history should be of interest.

About 1880, the Connellsville and Pittsburgh Railroad, now a part of the Baltimore and Ohio System, which parallelled the right bank of the Youghiogheny River from McKeesport to Pittsburgh, had its terminus at Grant and Water Streets.

The Pittsburgh, New Castle, and Lake Erie Railroad, subsequently known as the Pittsburgh and Western Railroad and now a part of the Baltimore and Ohio System, was built in 1877 and 1878, and extended from Allegheny City to Harmony and Wurtemburg, Pa.

The Pittsburgh, Cleveland, and Toledo Railroad was opened to traffic in 1884. Its route extended through the Mahoning Valley, eastward, from Akron Junction to New Castle Junction. At the latter point, it connected with the Pittsburgh and Western Railroad, thus providing a through line westward from Allegheny City, now Pittsburgh North Side, to Akron and Cleveland Harbor, Ohio.

By this time the industrial development of the Pittsburgh Harbor District had assumed considerable importance. An ample supply of coal and coke was available, but ore in large quantities could be obtained only through the harbors on Lake Erie. This ore movement was handicapped by the inadequacy of the railroad facilities. The necessity for a direct Lake route connection was recognized and the Baltimore and Ohio Railroad Company was prompted to seek an affiliation with either the Pittsburgh and Lake Erie Railroad, or the Pittsburgh and Western. A survey was made in 1880, with the object of securing a crossing of the Allegheny River at about the site of the present 7th Street Bridge and effecting a direct connection with the Pittsburgh and Western Railroad in the vicinity of its present passenger station. This project, known as the Pittsburgh Local Railroad, was incorporated on September 27th, 1880. The route as surveyed was unsatisfactory and other surveys were made in 1881. It was afterward suggested that the location of the Pittsburgh Local Railroad be changed from the Water Street Wharf to the present location of the Pittsburgh Junction Railroad. This arrangement was advisable, because the new route afforded a shorter, though more expensive, western outlet.

The Pittsburgh Junction Railroad was chartered on August 6th, 1881, and on October 1st, 1881, was consolidated with the Pittsburgh Local Railroad, the entire trackage of the two incorporations being designated as the Pittsburgh Junction Railroad.

It was decided to use 33d Street for the route of the Allegheny River crossing, and an ordinance by the City of Pittsburgh, dated July 30th, 1883, granted authority for a crossing of Liberty Avenue at grade. On March 1st, 1884, a contract was placed for the four double-track Main Channel spans, and on April 25th, 1884, the contract was placed for the three double-track Back Channel spans. The part of the structure on Herr's Island consisted mainly of embankment and fill. On April 25th, 1884, the contract was placed for the viaduct along 33d Street, which extended from Liberty Avenue to the first pier of the Allegheny River Bridge, a distance of 1 782 ft. The bridge which was completed and opened to traffic in 1884, served its purpose for more than thirty years.

The interval between 1884 and 1915 was marked by a steady increase in the weight of locomotives, with a corresponding severity of effect on bridges and roadbed. To meet these conditions, the structure was subjected to continual repair, careful maintenance, and alterations in order to adapt it to the imposed demands.

For about ten years preceding the reconstruction of this bridge, it was known that the limit of economic possibility in the use of the structure had been reached. Negotiations which had covered a period of years, were finally

concluded on September 30th, 1915, when the Secretary of War issued a permit covering the reconstruction of the river spans.

The Plans of 1915

As contemplated in 1915, the plan for the structure provided for raising the track about 14 ft., for the main river spans, and the placing of a double track, through truss span, 436 ft. in length, over the Main Channel, with a 265-ft., through truss span adjacent to and eastward thereof, and a through truss span across the Back Channel. The permit further stipulated that during the erection of the new bridge and the removal of the old structure, there be maintained between the two piers of the old Main Channel span, a clear opening of 150 ft. for the accommodation of river traffic. Falsework was to be placed for the remaining part of the Main Channel, as well as for the Back Channel, as necessary for the erection of the new structure.

The procedure contemplated was to erect the new channel spans on falsework, up stream from the existing structure, and to roll them to permanent line and elevation. The plans of the new structure provided a clearance of 51 ft. above Davis Island Pool, and a clearance of 44 ft. above the Herr's Island Pool which was 7 ft. higher than the Davis Island Pool. The center line of the two main-line tracks of the new structure coincides with that of the old, except that on Herr's Island, the tracks were to be re-located up stream from the previous location, the Herr's Island connection being placed immediately down stream from the new main line tracks.

An ordinance was passed on April 3d, 1915, providing that the tracks of the Railroad Company along 33d Street should be carried on a viaduct supported on two lines of columns, one on each curb line, thus avoiding the dangers of placing any part of the support over the sewer in the bed of 33d Street.

The Liberty Avenue crossing provided by the new structure, consisted of a solid floor, through, plate-girder span, about 66 ft. in length, and adjacent thereto, immediately eastward, a solid floor double-track, through plate-girder span, approximately 62 ft. long, continuing in that direction with four spans of double-track, open timber floor, deck-plate girders. Crossing Penn Avenue and Smallman Street, double-track, solid floor, deck plate-girder spans, 65 ft. in length, were placed. The tracks of the Allegheny Valley Railroad are crossed by a double-track, solid floor deck plate-girder span, 100 ft. in length. The remainder of the structure consists of 30-ft. towers, with intervening spans of suitable length. The old and the new viaducts are shown in comparison on Plate X.

The entire structure was designed for Cooper's E-60 loading, 14-ft. track centers, and 16-ft. clearance diagram. In order that in the future the new structure might be adaptable to the new main spans over the Allegheny River, it was decided to construct the new viaduct so as to accommodate a 1½% descending grade, to be used until the reconstruction of the river spans, at which time a 0.3% grade would be obtained. The contemplated future raise of grade was taken care of by the use of additional pedestal blocks, where the stringers were placed on top of the cross-girders, and, at the points where

PLATE X.
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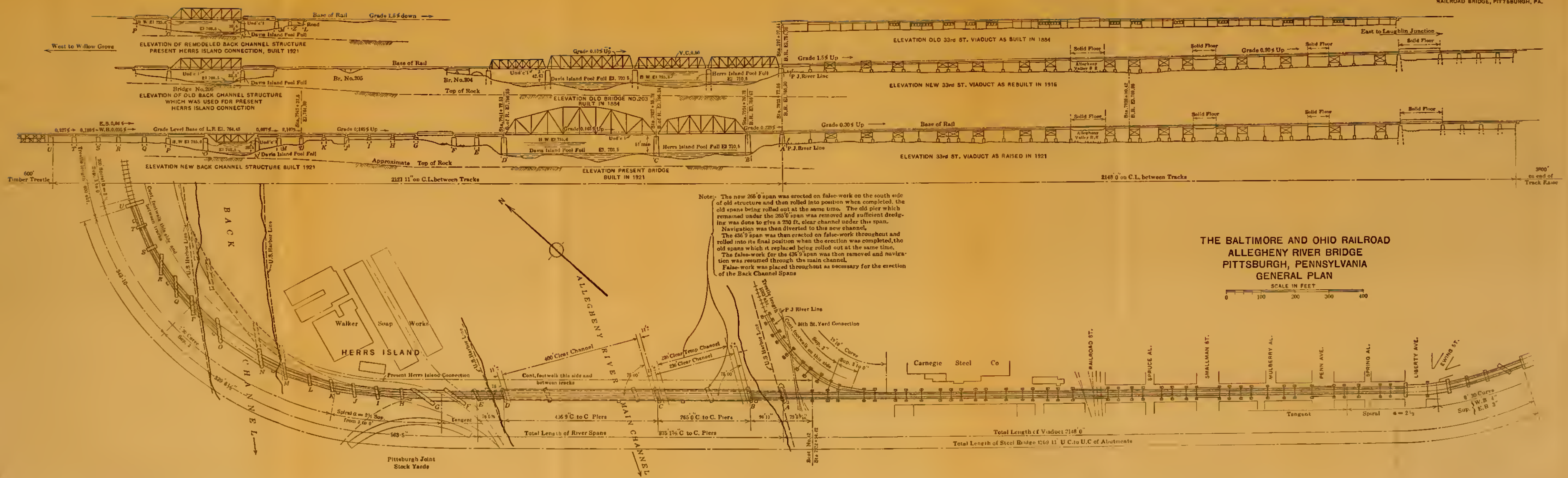
APRIL, 1922.
LANG ON
RECONSTRUCTION OF BALTIMORE AND OHIO
RAILROAD BRIDGE, PITTSBURGH, PA.



the stringers were framed into the cross-girders, by changing them to a position on top of the cross-girders, using suitable pedestal blocks. Where changing the stringers from framed-in to placing on top was not sufficient, arrangements were made to secure additional elevation by raising the cross-girders, the cross-girder connections, in this case, being detailed so that they could be readily elevated. In one double-track span, 30 ft. long, the girders could not be used, and new columns were also necessary at four of the bents, as well as additional miscellaneous material.

On May 31st, 1915, a contract was placed with the American Bridge Company, covering the fabrication and erection of the steelwork for the superstructure of the part of the structure from the abutment east of Liberty Avenue to the east bank of the Allegheny River. The total weight of steel entering into this viaduct was 7 354 238 lb.

On August 12th, 1915, a contract was placed with P. J. Joyce and Company, Incorporated, of New York City, covering the masonry substructure for this viaduct, and the date of completion was set for June 20th, 1916. The Company commenced operations on September 13th, 1915. In the meantime, on August 14th, 1915, the City had placed a contract for the raising of the Herron Avenue (formerly Forfar Street) Bridge, with John Eichleay, Jr., who commenced operations on September 17th, 1915.

Construction of 33d Street Viaduct

In March, 1916, the forces of American Bridge Company began the erection of the steelwork. It was necessary to consider the movement of traffic at this point, and make such adjustments as were needed to permit the handling of the reconstruction of the viaduct. Prior to beginning erection, single-track operation had been resorted to over this viaduct. It was deemed advisable, however, to divert all traffic to a temporary trestle constructed especially for this purpose. This trestle occupied, in general, the north sidewalk of 33d Street, between Liberty Avenue and the 36th Street Yard cross-over, and was built approximately to the new grade. This work was done in the spring and early summer of 1916, and traffic was transferred to the temporary high line on July 1st, 1916.

During the period in which the erection of this viaduct was in progress, the economic reaction of the World War was felt. The supply of labor was uncertain, the cost was rising, and it was necessary to concede several increases in the wage rate. On May 24th, 1916, the erection forces discontinued work, and remained idle until June 5th, 1916. During September, 1916, it was announced that, on all railroads, a basic 8-hour working day would become effective January 1st, 1917. In view of this fact, no precaution was spared to insure double-track operation over this viaduct by that date, and on October 16th, 1916, the east-bound track of the new viaduct was put into service. Traffic was placed over the west-bound track on October 22d, 1916.

Although a modern structure now extended to the east bank of the Allegheny River, its advantage was seriously impaired by the old and inadequate spans over the river. The supply of engines that could safely operate at this point had been reduced, and necessity demanded that the old spans,

during the remainder of their service, be utilized to the utmost; on October 23d, 1916, it became necessary to establish single-track operation over the river spans.

Plans for River Bridges

The reconstruction work on the 33d Street Viaduct had been followed with attention by the War Department, in view of its relation to the river spans and the fact that the viaduct and the river bridge actually constitute one homogeneous structure. On August 2d, 1916, the representatives of the Railroad Company were summoned to the United States Engineer's office, and questioned concerning the work on the river spans. It was then held by the Railroad Company that the work on the structure as a whole had been started, and that plans for the river bridges were in progress. The Railroad Company also stated that to undertake the reconstruction of the river spans prior to the completion of the 33d Street Viaduct was impracticable, because of the interference with traffic. The War Department extended the time limit one year which provided for the commencement of the work not later than September 30th, 1917, and its completion within three years.

The Secretary of War demanded the raising of the Allegheny River bridges below Herr's Island, to provide a 47-ft. vertical clearance above pool full, and those above that point 51 ft. The statement was made that the bridges were an obstruction to navigation, and that immediate elevation was necessary. In view of the negotiations already under way between the War Department and the Baltimore and Ohio Railroad Company, and the contemplated renewal of its bridge, that Company was omitted from citation in the War Department order of March 23d, 1917, under which notices were served on the County of Allegheny and the Pennsylvania Railroad Company.

The Declaration of War with Germany by the United States made immediate traffic and operating needs a prime consideration, and work was suspended during the remainder of 1917 and during 1918. By rigid traffic restrictions and careful maintenance, the old bridge was kept in service.

With the termination of hostilities, the reconstruction of the river spans was again considered, and early in 1919 negotiations were resumed with the War Department. Certain changes were advisable, and on March 10th, 1919, a modified plan of reconstruction, submitted by the Railroad Company, was approved by the War Department. This approval was based on construction, as shown by Plate X.

The engineering problems in connection with this reconstruction were intensified by the demand of the War Department that the work be conducted so as to permit navigation on the river at all times, by the necessity of building the new structure at an elevation approximately 14 ft. above that of the old bridge, and by right-of-way conditions which necessitated the maintenance of traffic within the property lines.

The structure involved in this improvement has a length of 2 122 ft., and extends from the west end of the 33d Street Viaduct, at the east bank of the Main Channel, to the abutment at the westerly end of the new structure. A series of girder spans were used for crossing the Island, and two truss spans,

265 ft. and 436 ft. 9 in., respectively, for crossing the Main Channel, thus providing clear channels for river traffic of 236 ft. and 400 ft., respectively, with a minimum overhead clearance above Davis Island Pool of 51 ft. The westerly approach consists of about 2 900 ft. of fill, and approximately 600 ft. of double-track, frame trestle supported on timber piles, between the fill and the west abutment of the main structure. The trestle is a temporary structure, and eventually will be replaced by an earth or slag fill. In general, the center line of the new structure coincides with that of the former bridge, except westward from about the center of Herr's Island, where there is a wide deviation. The fact that no traffic problem was involved in the construction of the west end of the new bridge greatly simplified the work.

Construction Features of New Bridge

The contract for the substructure was placed with the Vang Construction Company, of Cumberland, Md., on August 15th, 1919. Between the westerly end of the 33d Street Viaduct, indicated by Pier *A*, and the termination of the new steel bridge at Abutment *U*, Plate X, there are nineteen new concrete piers, designated by the letters, *B* to *T*, inclusive, occupying sites distinct from the old masonry, and their construction occasioned no interference, except at Pier *E*. The reconstruction of Pier *A* was not commenced until the new spans at that end had been placed, and then the new pier at this location was constructed on the old foundation which was in good condition and consisted of timber grillage on timber piles.

Piers *B*, *C*, and *D*, which support the 436 ft. 9-in. and the 265-ft. Main Channel spans, were built on timber caissons, sunk by the pneumatic process to footing on sandstone, about 63 ft. below the water level in the Herr's Island Pool. Borings were taken at the site of each pier prior to the commencement of this work.

The foundations for the Main Channel piers are from 14 to 16 ft. below what was at first thought to be suitable bearing strata. An unusual formation was discovered beneath the river bed. Below an apparently solid top course were thin layers of partly decomposed shale, separated by intervening mud strata. The caissons were nosed into the shale, and excavation was continued for a distance of from 14 to 16 ft. below the cutting edge.

The height to which these piers could be built was limited by the old bridge, and, in consequence, they were stopped temporarily at an elevation slightly below the under-clearance line of the old spans. The new spans were supported on steel columns, which were encased in concrete after the completion of the new superstructure to final line and grade.

The caissons used in the construction of these piers were built adjacent to the work, and consisted of timber boxes, 70 ft. long, 22 ft. wide, and 48 ft. high. Two muck shafts, 3 ft. in diameter, and one 3-ft. man shaft was provided in each caisson. The side walls of the working chambers were strengthened with reinforced concrete, and the roof of each consisted of a reinforced concrete slab. The combination of timber and reinforced concrete construction in such a manner as to provide sufficient buoyancy for the floating of the caissons to their sites is worthy of note.

Pier *E* was located at the center of the arch of the old west arch abutment, and it was found that the area covered by the old arch was paved with two courses of stone masonry, supported on two layers of 12 by 12-in. timber and one layer of 4-in. planking, the entire area being supported by timber piles, spaced approximately 3 ft., center to center. This pier was sunk by means of a pneumatic caisson to a support on the old timber piles, about 17 ft. below the level of the Herr's Island Pool.

The piers on Herr's Island were footed on concrete piles, and as it was possible to detour the traffic on the single-track timber trestle, placed alongside the permanent alignment, these piers were built to final elevation before placing the steel. Piers *M* to *P,* inclusive, were footed on sandstone about 23 ft. below Herr's Island Pool. Pier *M* was built on a caisson, pneumatically sunk; the other three piers in this group were built by means of open coffer-dam, although, with Pier *N,* an air bell, operated by pneumatic equipment, was used. Piers *Q, R, S, T,* and Abutment *U* are supported on concrete piles.

The conditions at Pier *N* (Fig. 2), which led to the use of an air bell were unusual. The depth from pool full to river bottom at this pier, was about 12 ft., and the underlying soil consists of 4 ft. of sand and gravel, under which is a layer of shale or sandstone. With the object of reaching a sandstone foundation, the site was dredged to a depth of 18 ft., and a coffer-dam was constructed of a single row of interlocking sheet piles which enclosed the pier and the adjacent area. The area inside the coffer-dam was dredged within 1 ft. of rock, and the excavated material was utilized for banking the walls of the coffer-dam.

When an attempt was made to drain the coffer-dam, considerable leakage occurred, being especially marked adjacent to the old masonry pier, to which the coffer-dam was joined by pockets filled with clay and sealed against the old foundations, thus creating an element of danger.
the old pier and it appeared to have been constructed on timber cribbing. On account of the perceptible vibration of the old pier by passing trains, the pumping was discontinued, as this operation tended to draw water through the old foundations, thus creating an element of danger.

To avoid the possibility of danger, it was decided to use an air-bell for completing the excavation and for depositing the concrete for the new pier. Since the foundations for Piers *B, C,* and *D,* had been completed previous to the operations at Pier *N,* a compressor plant and a force of "sand hogs" were available. The inside dimensions of the coffer-dam were 17.5 ft. by 58.5 ft., the outside dimensions of the air bell being 12 ft. by 48 ft., with a height of 5 ft. 0 in. This air-bell was constructed on Herr's Island, adjacent to the work, and was hoisted above the coffer-dam by a derrick boat, with three air-shaft sections attached. The bell was sunk to the bottom inside the coffer-dam, with a space of 2 ft. 6 in. between the sides of the air bell and those of the coffer-dam. This space was filled with tremie-deposited concrete, the bell completely covered, and its top and sides were sealed, after which the water was pumped from the coffer-dam, and the concrete was deposited in the dry, to the water level.

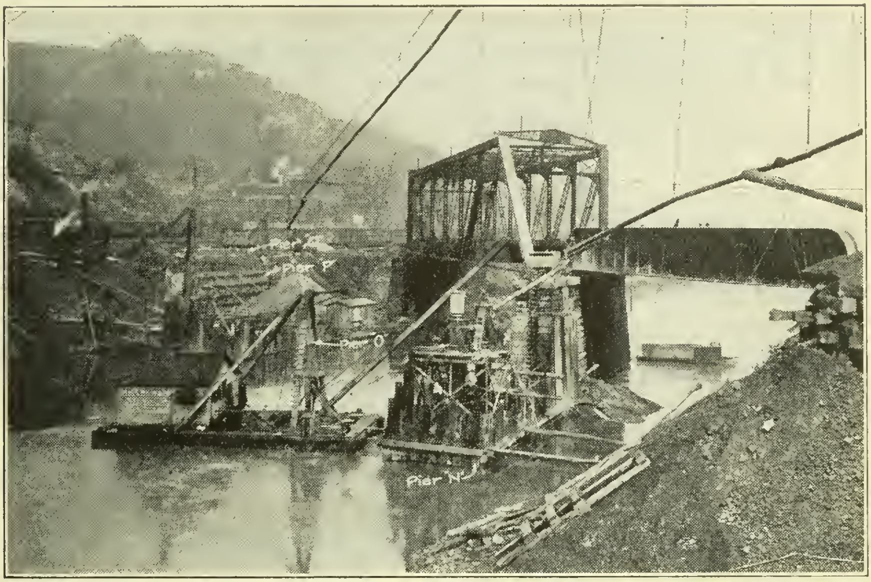


FIG. 2.—VIEW OF PIER *N*.

FIG. 3.—NEW SPANS *AB* AND *BC* IN PLACE AT FINAL ALIGNMENT.

Air pressure was then applied to the bell and the water inside expelled. The underlying soil was removed, and as the rock was quite soft, excavation was continued 6 ft. into the sandstone. The concreting of the excavation, including the interior of the bell, was then performed under air pressure. The bell was of light construction, and the conditions under which it was used were distinct from those prevailing in the construction and use of ordinary pneumatic caissons. The absence of launching stresses or cutting-edge stresses, and the fact that the interior air pressure was resisted by the concrete enclosing the bell, conferred further advantages in this operation.

In the construction of the bell, 3 by 8-in., ship-lap pine sheathing was used, which was spiked to nine 6 by 10-in. pine cross-frames. The experience with the problems at Pier *N*, as described, indicates that the air-bell method as adopted was the most economical.

The plant of the Vang Construction Company at this point included a steel concreting tower, 225 ft. high, from which, after being mixed at a central plant, most of the concrete was deposited by chutes. Dinkey equipment was used to deliver the concrete to those points where it was impossible to deliver it by the chutes. A complete air-compressor plant was located at a site selected to meet the needs of the work. Although the work on the substructure for this bridge was carried on through a severe winter, which handicapped the operations of the contractors, an excellent record was maintained.

Erection Methods

Shipments of steelwork began to arrive at the bridge site early in May, 1920. The original intention was to use a sub-divided truss of 14 panels for the 436 ft. 9-in., through, truss span, *C D*, and 9 panels for the 265-ft. through, Pratt truss span, *BC*. The design finally developed for the 436 ft. 9-in. span was a simple triangular truss of 10 panels, having 20 panel points and 29 members per truss. The simple form of truss adopted eliminated secondary stresses to a great extent.

The work of erection began in June, 1920, and proceeded simultaneously from each end of the new steel structure. In scheduling this work, the contemplated grade change and the necessity for establishing the final grade at an elevation approximately 14 ft. above the old grade, were considered. As stated previously, the line of the new structure diverges from that of the old in its westerly portion, near the Back Channel. The old Back Channel structure has been retained and adapted to single-track operation. This required the placing of a new floor in two of the old spans, the remainder of this structure consisting of the new single-track Herr's Island connection, crossing the Back Channel, which is designed for Cooper's E-50 loading.

Since the new and the old alignment coincide at the east bank of Herr's Island, a temporary single-track detour was constructed over the Island on the up-stream side of the permanent line. The plate-girder spans which form the viaduct at the west end, from Abutment *U* to Pier *G*, were erected in final position. The through plate-girder span, *FG*, was erected 14 ft. south of its final location, that is, its final west-bound track was used temporarily on the location of the east-bound track, this arrangement being made in order

that the overhead clearance required for the connection track to Herr's Island could be obtained, and in view of the necessity of obtaining adequate lateral clearances for the detour track. The east-bound track on Span *FG,* in this position, served the purpose of an erection siding, providing access to the 434-ft. span in its temporary position down stream from the old structure. In order to provide suitable lateral clearance for this track, it was further necessary to cut one corner of Pier *G,* and use a plumb face. The deck plate-girder spans, *DE* and *EF,* could not be erected in their final location, due to interference with the detour track.

At the east end of the structure, the 97-ft., deck plate-girder span, *AB,* and the 265-ft., through truss span, *BC,* were assembled and erected at the old or low level, on falsework extensions to the new piers (Fig. 3), built down stream from the bridge, falsework extensions to the old piers, for the support of the two old truss spans in their rolled-up position, being made on the up-stream side of the structure. During the erection of the 265-ft. truss span and the 97-ft. girder span, at the east end of the river structure, the river traffic passed under the third span from the east bank of the old bridge. After the 265-ft. through truss span had been moved to final line, the old pier beneath it was removed, and the channel dredged under the new span. The movement of river traffic was then shifted to this opening, and the falsework for the 436 ft. 9-in. channel span was placed. This method of disposing of the traffic on the river made it possible to erect both these spans on falsework, and obtain a completely riveted structure.

The 97-ft. girder span, *AB,* at the east end of this bridge, was supported in temporary position on double pile bents of 8 piles per bent, located down stream from the present structure. A connection was made between the tracks on this span and the east-bound track on the 33d Street Viaduct by a trestle and turn-outs. The west end of the 97-ft. girder span was fitted with special brackets which seated on the end floor-beams of the 265-ft., through truss span that carried the west end of the deck plate-girder span during the rolling operation.

For rolling, the east end of the 97-ft., deck plate-girder span, that is, at Pier *A,* was carried on two nests of rails of four lines each, with rollers between, 3 in. in diameter, spaced 8 in., center to center. The falsework for the 265-ft. span consisted of seven bents, one under each intermediate panel point, braced transversely with timber bracing and longitudinally at every other panel point by four lines of cross-bracing and by girts placed at the tops of the bents and also just above the water surface. Each bent consisted of nineteen piles, about 57 ft. long. I-beams were placed on top of the caps of the pile bents to distribute the panel loads.

To support the span during erection and during the rolling operation, the down-stream pier extensions, at Piers *B* and *C,* were made strong enough to permit the swinging of the span, thus supporting it as a simple span from end to end. At Piers *B* and *C,* additional castings 2 ft. 6 in. high were placed at the final location of the truss shoes, between which I-beams were placed, and bolted to the castings. I-beams were also placed from the end of the pier to the falsework supporting the new span; the tops of the I-beams, to-

gether with the steel castings, furnished a continuous, smooth surface, on which the rolling took place.

The new span was moved on rollers, 3 in. in diameter, spaced 4 in., center to center. The power for the rolling operation of September 1st, 1920, was furnished by two locomotive cranes and a derrick car, distributed as follows: One locomotive crane at the ground elevation, near the up-stream end of Pier *A;* one locomotive crane at the east end of the 265-ft. span, at Pier *B;* and one derrick car at the west end of the 265-ft., through truss span, at Pier *C*.

The old spans were placed on rollers, 3 in. in diameter. These spans were blocked to the new spans, and were pushed out of place by the movement of the latter to final position.

Constant check of the movement of the spans during the rolling was maintained by transit observations on range boards. The cranes, derrick car, and the old and the new piers, were connected by telephone. The foreman and field engineer in charge of the operation were located at the telephone central, and thus had direct communication with all points of movement.

On September 1st, 1920, the 265-ft., through truss span, *BC,* and the 97-ft., deck plate-girder span, *AB,* were pulled to final line at the old grade (Fig. 3), and, simultaneously, two old truss spans, extending from old Piers Nos. 1 to 2 and 2 to 3, were withdrawn to a temporary position on the up-stream pier extensions. The total length of the old spans removed in this operation was about 412 ft., while the length of the new spans moved into place was about 360 ft., which left a gap of about 54 ft. between the new steel and the easterly end of the old span between Piers Nos. 3 and 4. This gap was bridged temporarily by a single-track, deck, plate-girder span, about 50 ft. in length, which was floated on barges to a position directly under the opening. After the movement of the two long spans, a derrick car was moved to the westerly end of the 265-ft. span, *BC,* and the 50-ft. girder span was raised from the barges and bolted into temporary position.

The chronology of the various operations incident to the performance of the work on September 1st, 1920, is briefly summarized, as follows:

10:00 A. M.—The track was broken.

10:10 A. M.—Started rolling the two spans.

10:27-10:30 A. M.—Spans reached final line, rolling ceased.

11:30 A. M.—Both ends of the truss span landed; rollers removed and track connection made at the east end, Pier *A*.

11:45 A. M.—Started to lift temporary girder span to be placed between new Pier *C* and the old pier in the middle of the river, this girder span having been provided with timber deck and rails, and placed on barges immediately below the opening.

12:00 M.—Temporary girder landed.

12:10 P. M.—Track in satisfactory condition at east end of bridge, work train removed derrick car from the structure.

1:03 P. M.—First train passed over the bridge.

1:20 P. M.—First passenger train passed over the bridge.

The total period of interruption to traffic was 3 hours 3 min. The period of 17 min. 30 sec. does not represent the actual time required for the movement of these spans, which was only 6 min., the difference, 11 min. 30 sec., was consumed by stopping the rolling operation three times, in order to check the position of the spans, and to make sure that all equipment was functioning in a satisfactory manner. The weight rolled was, as follows:

Span AB:	
Weight of new steel	318 000 lb.
Weight of deck	118 000 "
Span BC:	
Weight of new steel	2 098 000 "
Weight of deck	262 000 "
Approximate weight of equipment on span	670 000 "
Two Old Spans:	
Weight of metal	1 200 000 "
Weight of deck	310 000 "
Total weight	4 976 000 lb.

The old spans were then dismantled. The floor system and the top and bottom lateral bracing of old Span No. 2 were removed, after which the trusses were skidded to the new bridge, lashed to it, and dismantled. This procedure was impossible in dismantling old Span No. 1. After the floor system and laterals were removed, the trusses were lowered into the river, and then removed.

When this operation was completed, preparations were made for the placing of the 436 ft. 9-in., through truss span. At this stage of the work, all traffic was carried on a single-track line, on the west-bound side, from the crossing of the 33d Street Viaduct over the tracks of the Allegheny Valley Railroad, over new Spans *AB* and *BC,* the temporary girder span, and the two old truss spans, to Herr's Island, thence over the detour trestle and the old Back Channel spans on the low level.

The remaining work may be divided into five parts, namely:

I.—The raising of the east-bound track on the 33d Street Viaduct, from the Allegheny Valley Railroad Crossing to Pier *A,* a distance of 921 ft.

II.—The rolling into final position, at high level, of the 436 ft. 9-in., through truss span, *CD,* and the deck plate-girder span, *DE.*

III.—The rolling of the through plate-girder span, *FG,* a distance of 14 ft.

IV.—The placing of deck plate-girder span, *EF.*

V.—The jacking of the 265-ft. through truss span, *BC* to the new grade.

The raising of the east-bound track on the 33d Street Viaduct was started promptly, the stringers alone being raised, and, where necessary, temporary steel pedestals and bents were provided between the bottom of the stringers

and the top of the cross-girders. This temporary steelwork was scrapped after both tracks of the viaduct had been raised and the cross-girders brought to their final elevation. The deck plate-girder span under the east-bound track in Span *AB* was also raised when the east-bound track on the 33d Street Viaduct was elevated. It was necessary, therefore, that Operations II, III, IV and V, be carried out at one time, when all traffic would be abandoned. The final change was made on December 20th, 1920, according to a plan each step of which was carefully arranged in advance.

The jacks and pulling tackle were tested the day before. The alignment of the moving spans was maintained by transit observations on horizontal gauge boards, the foreman, transitmen, and engine operators, were provided with telephones.

The weight involved in the rolling operation of December 20th, 1920, was approximately, as follows:

Truss Span CD:	
Steelwork	4 788 000 lb.
Timber deck	437 000 "
Equipment on span	720 000 "
Deck Plate-Girder Span DE:	
Steelwork	194 000 "
Timber deck	90 000 "
Two Old Truss Spans:	
Metal work	1 204 000 "
Timber deck	315 000 "
Total weight	7 748 000 lb.

The approximate distribution of this load at the respective bearing points was:

Pier *C*	2 972 000 lb.
Pier *D*	3 114 000 "
Pier *E*	143 000 "
Total	6 229 000 lb.

Prior to December 20th, 1920, the entire bridge was in operation at the low level, with only the west-bound track in service, as the east-bound track on the 33d Street Viaduct was being raised to take traffic at the new grade, after the final change of the river span.

At Piers *C* and *D* (Fig. 4), the rigging consisted of 20-part tackles, $\frac{3}{4}$-in., steel rope, and at Pier *E*, an 8-part tackle and $1\frac{3}{4}$-in. manila rope. The roller nests consisted of rollers, 3 in. in diameter, 8 ft. in length, spaced 4 in. center to center, held by side-bars perforated to admit the ends of the rollers. Practice has shown that a load equal to the usual loading of expansion rollers is satisfactory, and data are available on the friction to be expected. The calculated roller load was 1 960 lb. per lin. in. of roller, or about 650 lb. per lin. in. of roller per inch of roller diameter. The rolling friction was assumed to be

0.006, based on a 1-ft. diameter of roller, or 0.024 for the roller 3 in. in diameter. Experience indicates that this amount is about 20% too high, when the track is supported so that no local crushing occurs.

The 436 ft. 9-in. channel span was erected at the elevation of the new structure; steel bents were provided to support it on the new piers after it had been rolled to final position on these piers which were about 14 ft. below their final height. As the shoe-plates of the new span were a little below the rail level of the old spans, it was possible to place the steel bent on Pier *C* without fouling the track, and this bent was moved in with the 265-ft. span. Pier *D* at the other end of the span, however, was located under the old structure, so that this bent could not be erected. It was built on falsework, as a part of the new span, with which it was moved into place.

The connection between the new and old spans was made by placing wooden blocking and struts between the posts of the two spans at a number of points. The force necessary to move the old spans thus had to be resisted by the lateral bracing of both the old and the new spans.

The falsework extensions provided for the erection and movement of the new span consisted of two 8-pile bents at each panel, each capped with one 12 by 12-in. timber and two 24-in. I-beams. At Pier *C,* the support consisted of pony bents framed on top of the timber pier extensions, which, capped at the low level, had served for the movement of the 265-ft. span. At Pier *D,* the new bent was framed to the full height. The track for the rolling consisted of five 30-in. girders.

Preliminary to the rolling, the old spans, the withdrawal of which was included in this operation, were raised by hydraulic jacks, four of which were placed under the end of each span. The jacks worked against short lifting girders, from which were suspended wire rope slings attached to the end pins of the respective spans. When the spans had been raised a sufficient distance, rollers were inserted, on which the spans were permitted to take bearing; the remainder of the roller nests were then introduced in the spaces between the shoes, and linked together. Rollers had been placed under the new span before it was swung. When the movement had been completed, the roller-nest segments between the shoes of the new span were disconnected and removed, after which the span was raised by jacks placed under the end floor-beams, to permit the removal of the rollers under the shoes.

The pier bent at Pier *D* was braced by struts extending from the base of the bent to the first panel point of the bottom chord of the span. At Pier *C,* the rockers of the expansion bearing, on which this span rested, were blocked by locking plates until the completion of the movement and the removal of the rollers.

The weather on Monday, December 20th, 1920, was ideal for the operation. After east-bound train No. 6 had passed, at 7 A. M., the track was cut. The temporary girders between Pier *C* and the east end of the old span were lifted out by the derrick car, and carried out of the way. The track was also cut at Pier *E,* to remove the I-beams carrying the detour or operating track across that pier. This left the pier clear for the rolling of the new spans, *CD* and *DE,* and the withdrawal of old Spans 3 and 4. (Fig. 5.) Two locomotive

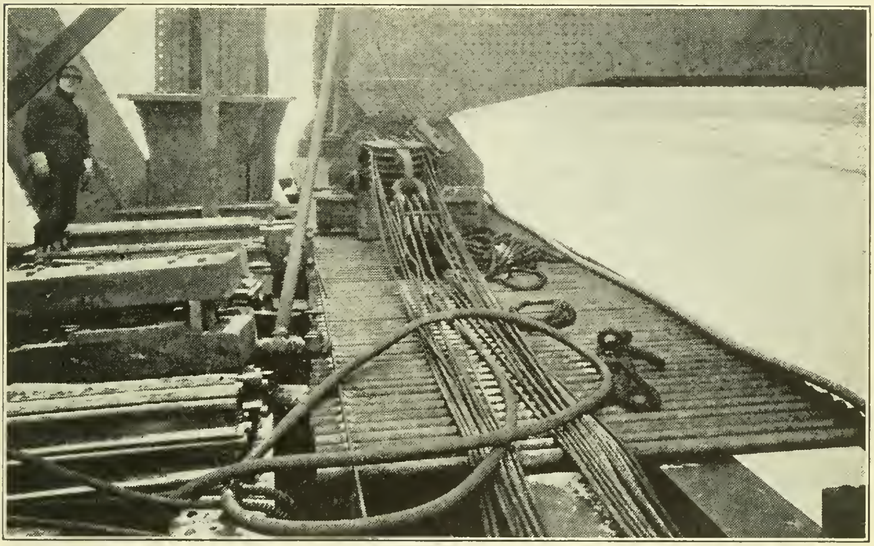


FIG. 4.—PULLING TACKLE AT PIER *C*.

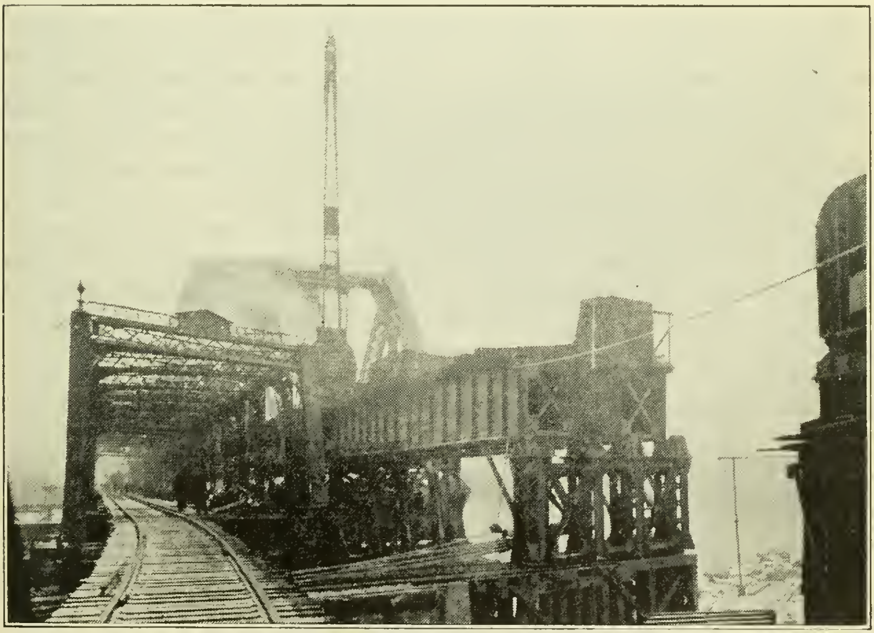


FIG. 5.—OPERATING TRACK OVER OLD SPANS AT LOW LEVEL. NEW SPANS *CD* AND *DE* BEFORE ROLLING.

cranes on the long truss span and a derrick car on the new west approach furnished the power for this operation. As soon as the new spans were in final position, they were jacked up to remove the rollers, and then lowered to permanent bearing on the masonry. The movement was accomplished in 14 min. actual moving time; and the total distance moved was 38 ft. $7\frac{7}{8}$ in., making an average of nearly 3 ft. per min.

The chronology of operations in connection with the movement of the 436 ft. 9-in. through truss span and deck plate-girder span, *DE,* and the withdrawal of the two old truss spans replaced by them, is as follows:

7:00 A. M.—Track severed, immediately after the passage of east-bound train No. 6.
7:17 A. M.—Derrick car arrived at Pier *C,* for removal of temporary 50-ft. single-track deck plate-girder span.
7:40 A. M.—Locomotive crane arrived at Pier *E,* for the removal of parts of the detour trestle.
8:00 A. M.—Rolling of Spans *C D* and *D E* started.
8:54 A. M.—Rolling completed, total time 54 min.; actual time of rolling, 14 min.
10:15 A. M.—Span *D E* landed on Pier *E.*
10:23 A. M.—Span *C D* landed on Pier *C.*
11:30 A. M.—Span *C D* landed on Pier *D.*
12:00 M.—Span *D E* landed on Pier *D.*

As previously stated, the west-bound track deflected to the right, from the west end of the old river bridge, reaching a detour alongside the new west approach, which was maintained while this approach was being erected to final alignment. This viaduct was built complete to within three spans of the river bank, which spans had to be left until the final change, on account of interference with the detour.

While the work of removing the rollers from under the channel span was in progress, the steel bent on Pier *F* was extended to permit the rolling of through plate-girder span, *FG,* to final position. The rolling of this span started at 12:06 P. M., and was completed at 12:14 P. M., the total elapsed time of rolling being $5\frac{1}{4}$ min. Immediately after the placing of this span, the girders for Span *EF* were erected by derrick cars.

As soon as the 436 ft. 9-in. channel span had been moved to final position (Fig. 6), and the two old truss spans replaced by it had been withdrawn, the jacking of the 265-ft. through truss span to the new grade commenced, and was finished at 12:45 A. M., December 21st, 1920.

Jacking operations are difficult and complicated, whereas in the rolling of bridge spans there is little danger since breakage of the pulling tackle or failure of the power merely stops the movement.

Jacking is also a tedious operation; each lift is measured in inches, and the lifting is frequently stopped for re-setting. It is further essential that, as the load is raised, adequate supports must be provided to sustain it, which accounts for the great amount of time required for such work. Jacking operations involve an element of danger, and this procedure was adopted in the present instance only as a matter of necessity.

The 265-ft. through truss span was lifted a distance of 13 ft. 2⅝ in. at the east end, Pier *B*, and 15 ft. 2⅝ in. at the west end, Pier *C*. The load lifted was about 1 200 tons, or 600 tons at each pier. Four hydraulic jacks, each with a capacity of 500 tons, were used at each pier, in sets of two working and two idle. These jacks had a run-out of 26 in. By lifting the idle pair of jacks with the span, setting blocking under it, and then using these jacks for a further lift, a continuous lifting operation was possible. In order to avoid the carrying of the blocking to undue heights, the steel columns on which the span was to rest, were made in three sections.

To provide transverse bracing for the sectional columns, sectional girders or diaphragms were placed between the two columns as the raising progressed. These girders were used to support the jacks, and it was unnecessary, therefore, to build blocking for the jacks to the full height of the lift. After setting one story of the columns in place, it was necessary to lower the span on the columns, raise both jacks and remove the blocking under them, and insert the girder section between the columns. For the further operation, the jacks rested on the girder as previously they had rested on the pier. Two girders were provided at the west end of the span and three girders at the east end.

The lift was accomplished at each end in three successive raises of about 4 ft. each. A fourth lift was made at Pier *C*, for the purpose of inserting a cast pedestal intended to equalize the shoe heights of the two adjoining spans.

The piping was arranged so that at each pier the two spans were jacked as a unit. For the first fleet of jacks, both ends were carried up together; after that, the two ends were jacked separately. While this process was being carried on, the span was being followed up by rail grillages placed on top of the partly completed columns, arranged in such a manner that only one-half of this grillage was removed until the next column section was slipped half way into place. As a further safeguard, the heads of the jacks were followed by filler-plates surrounding the plungers.

All preparations on the two piers having been made in advance, the jacking started at 9 A. M., December 20th, 1920, and proceeded continuously, being completed shortly after midnight. The work of placing the girders between the pier columns proved slow, because of the skew of the girders with respect to their end connections and the columns. Work after dark also proved slow. (Fig. 7.)

Connecting up the new track required another hour after the span was entirely landed and secured. At 1:40 A. M., December 21st, 1920, the track was ready for traffic, and at 1:45 A. M., the first engine passed over the new structure, on the east-bound track, the only track in service at that time.

Before train service could be turned over the west-bound track, and double-track operation started, it was necessary to raise the girders for that track on the viaduct along 33d Street to the new grade. As already explained, provision for such a raise of grade was made when this viaduct was built; this was done by framing the first sixteen spans of longitudinal girders adjacent to the bridge between cross-girders of the steel bents, while all the remaining girders of the viaduct were placed on top of the cross-girders. The raise of

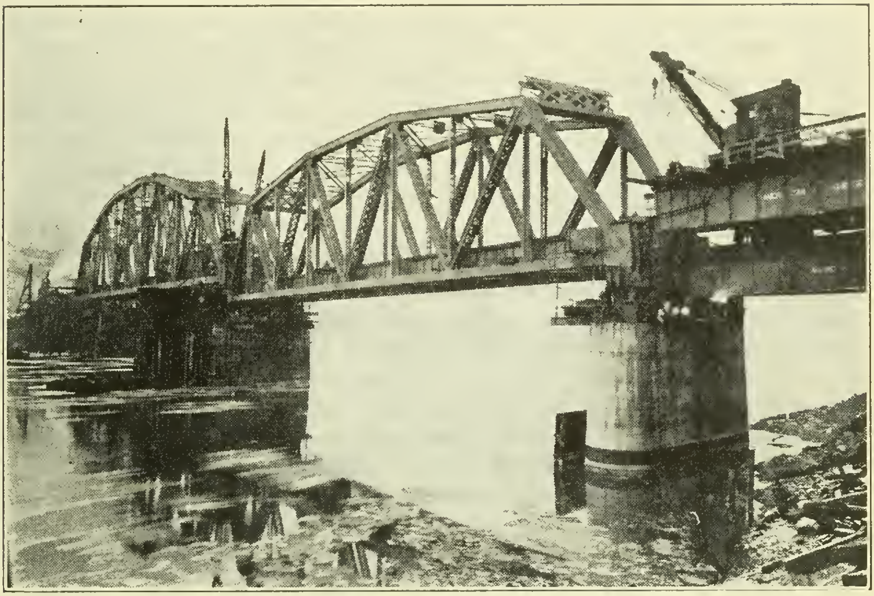


Fig. 6.—436 Ft. 9-In. Span and One Plate Girder Span in Final Position. 265-Ft. Truss Partly Raised.

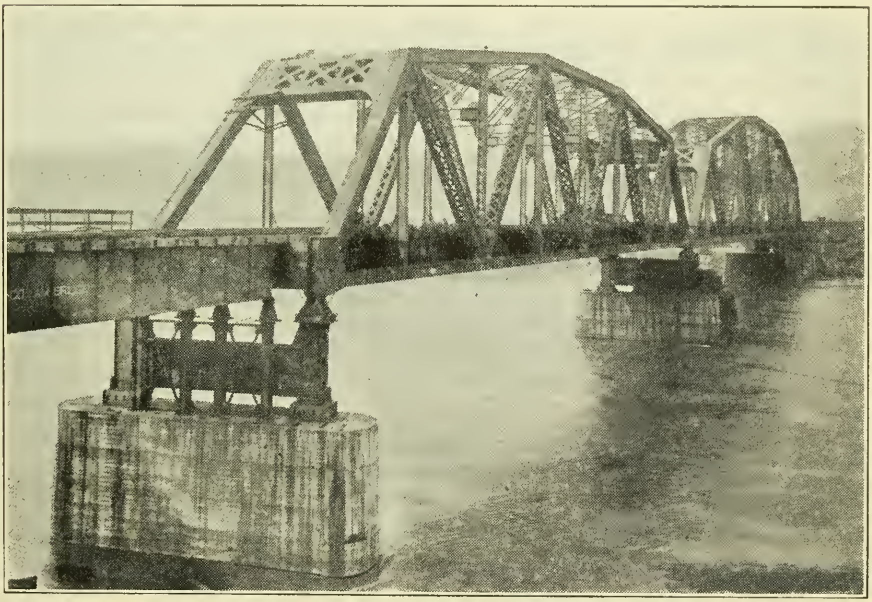


Fig. 7.—Main Channel Spans Supported on Steel Bents.

grade was accomplished, therefore, by shifting the longitudinal girders from between the cross-girders to the top flanges, supplemented by the use of shims or blocks of varying thickness; a further raise of grade in the seven spans nearest the river bridge was provided by designing the connections of the cross-girders to the columns so that the cross-girders could be moved a variable distance on the columns. As this last change could not be made until the girders for both tracks were raised, the girders for the east-bound track, which were raised first, were supported on temporary steel pedestals placed on top of the cross-girders.

During the time that traffic over the bridge was suspended, on December 20th, 1920, local passenger trains running west of Pittsburgh operated in and out of the Allegheny Passenger Station, while all through passenger trains were operated over the Pittsburgh and Lake Erie Railroad, between New Castle Junction and McKeesport.

With the completion of the major operation on December 20th, 1920, the concluding phases of the work were prosecuted with vigor, including the raising of the west-bound track on the 33d Street Viaduct to the new grade, already mentioned. On Thursday, January 27th, 1921, traffic into the 36th Street Yard was suspended at 7:30 A. M. At 2:40 P. M., Thursday, February 10th, 1921, the 36th Street Yard connection was put into service.

Traffic was likewise abandoned over the Herr's Island connection track crossing the Back Channel, while the floor system of this structure was being changed; train movement was resumed over this track at 3:45 P. M., Tuesday, March 15th, 1921.

At 7:00 A. M., Wednesday, March 16th, 1921, the west-bound track over the river bridge was thrown open to traffic.

Double-track operation was established over the river spans on March 16th, 1921, although this improvement was not formally placed in the hands of the Operating Department until Saturday, June 11th, 1921.

The approximate quantities involved in this work are as follows:

For the elimination of Liberty Avenue grade crossing and reconstruction of 33d Street Viaduct:

Superstructure:	
Weight of new steelwork, in pounds	7 354 000
Timber deck, in feet, board measure	450 000
Concrete in solid floor spans, in cubic yards	459
Water-proofing in solid floor spans, in square yards	900
Substructure:	
Total cubic yards of concrete in piers, abutments, pedestals, and retaining walls	19 800
Total linear feet of concrete piles	43 200
Total cubic yards of excavation	13 000
Total cubic yards of fill	35 000
Total cost	$756 653.32

For the reconstruction of Allegheny River Bridge, crossing Main Channel, Back Channel, Herr's Island, Herr's Island connection, and 36th Street Yard

connection, including raising of 33d Street Viaduct West of the Allegheny Valley Railroad Crossing, July, 1919, to June, 1921:

Raising 33d Street Viaduct:	
Superstructure: new steelwork, in pounds.	396 305
265-ft. Truss Span *BC:*	
New steelwork, in pounds	2 098 000
436 ft. 9-in. Truss Span *C D:*	
Superstructure: New steelwork, in pounds	4 788 000
Through Plate-Girder Span *FG:*	
New steelwork, in pounds	412 850
Deck Truss Span *NO,* crossing Back Channel:	
New steelwork, in pounds	849 284
36th Street Yard Connection:	
New steelwork, in pounds	529 502
Single-track Herr's Island Connection over Back Channel, including new floor system:	
New steelwork, in pounds	686 814
Remainder of structure, consisting of deck plate girders between Pier *A* and the west abutment, *U:*	
New steelwork, in pounds	3 551 545
River and island structure:	
Total weight of steelwork, in pounds	13 312 300
New steel structure:	
Total quantity of timber in floor system, in feet board measure	604 000

The substructure for the river and island spans contains the following approximate quantities:

Concrete, in cubic yards	26 100
Concrete piles, in linear feet	25 600

In the trestle approach west of Abutment *U,* and the trestle approach on the 36th Street Yard connection, the following approximate quantities are used:

Timber piles, in linear feet	24 000
Timber, in feet board measure	480 000

The fill at the west end of the structure, and the fill on the approach to the 36th Street Yard connection required a total of 84 000 cu. yd.

The cost of the elimination of the grade crossing at Liberty Avenue, the reconstruction of the 33d Street Viaduct, the river, Island and Back Channel structures, and other incidental work, amounted to approximately $3 000 000.

Organization

In the reconstruction of the 33d Street Viaduct, and the grade-crossing elimination work incident thereto, the interests of the Railroad Company were placed in the general charge of Francis Lee Stuart, Chief Engineer, M. Am. Soc. C. E., and of R. N. Begien, M. Am. Soc. C. E., who, on Mr. Stuart's resignation on July 10th, 1916, succeeded him as Chief Engineer. The work on the superstructure, including the preparation of general and detail plans, fabrication of steelwork. and erection, was under the immediate supervision

of Mr. W. S. Bouton, Engineer of Bridges. Paul Didier, M. Am. Soc. C. E., Principal Assistant Engineer, was responsible for the field work, and it may be mentioned, as a matter of interest, that Mr. Didier was also connected with the original bridge construction at this point, in 1883-84.

In the reconstruction of the river and island structure, the Railroad Company's interests were placed in the general charge of H. A. Lane, M. Am. Soc. C. E., Chief Engineer. The superstructure work, including the preparation of general and detail plans, fabrication of the steelwork and erection in the field, was under the supervision of Mr. W. S. Bouton, Engineer of Bridges, until October 24th, 1919, and, from that date until the completion of the work, under that of the writer. The field work was under the supervision of Mr. A. C. Clarke, District Engineer, represented at the site by Mr. W. M. Ray, Assistant Engineer. The services of J. E. Greiner, M. Am. Soc. C. E., Consulting Engineer, were retained, and he was represented at the site by E. W. Stearns, M. Am. Soc. C. E. The American Bridge Company, placed in charge of the erection J. L. deVou, M. Am. Soc. C. E., Division Erecting Manager, N. H. Orr, Assoc. M. Am. Soc. C. E., Assistant Division Erecting Manager, and Mr. Sherman Frantz, Superintendent.

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PAPERS AND DISCUSSIONS

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TENTATIVE PLAN FOR THE CONSTRUCTION OF A 780-FOOT ROCK-FILL DAM, ON THE COLORADO RIVER, AT LEE FERRY, ARIZONA.

By E. C. La Rue,* M. Am. Soc. C. E.

Synopsis

It is proposed to build a rock-fill dam in a narrow canyon of the Colorado River by blasting in the canyon walls. The dam described in this paper was designed to raise the water 700 ft. above the bed of the river. Both the height of the dam and the plan suggested for its construction are unique features. The walls of the canyon rise 1 300 ft. above the river, and the width of the canyon at the water surface is 450 ft.

During the past six years, the writer has had in mind the plan herein outlined for the construction of such a dam. As a dam of this type may be built on the Lower Colorado within the next year or two, it is believed that the presentation of this paper at this time will be of interest to many engineers. There may be a difference of opinion as to the feasibility of the plan as presented. Some engineers may have studied this problem carefully, but to the writer's knowledge no one has ever made the results of his studies available to the Engineering Profession. It is hoped that engineers will present their views in the form of constructive criticism of this paper.

Introduction

In the southwestern part of the United States, the demand for power is increasing rapidly. In California alone, construction plans which call for the expenditure of several hundred million dollars, have been adopted for the development of hydro-electric power. As a result of these plans, the ultimate development of the power resources of the Sierra Nevada and Coast Range Mountains, in the southern part of California, is in sight.

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Hydraulic Engr., U. S. Geological Survey, Pasadena, Cal.

The construction of high rock-fill dams by blasting down the towering canyon walls has been suggested in connection with the studies of both power and irrigation development. This paper deals primarily with the practicability of constructing such a dam in the Colorado River. A particular site (Lee Ferry) has been chosen, in order that the discussion might be based on definite dimensions. It should not be construed, however, as advocating this or any other specific project.

Colorado River Basin

General Features.—The Colorado River is formed by the junction of the Green and Grand Rivers in Southeastern Utah. The combined length of the Green and the Colorado is 1 700 miles and the total fall is about 14 000 ft.

The Colorado River and its tributaries drain an area of 244 000 sq. miles. This area comprises the southwestern part of Wyoming, the eastern half of Utah, the western part of Colorado, practically all of Arizona, and small parts of California, Nevada, New Mexico, and Mexico. (Fig. 1.)

The water resources of the Colorado River Basin are enormous. About 14 000 000 acre-ft. of water is wasted annually into the Gulf of California. Practically all this water could be used for irrigation and, in addition, a large amount of hydro-electric power could be developed. In order to utilize fully the water resources of the Colorado River Basin, the flow must be regulated to meet the demands for both irrigation and power. The storage of the flood waters would serve a threefold purpose: Water would be available for irrigation when needed; the possibilities for the development of hydro-electric power would be greatly increased; and with the ravaging floods under control, property on the lower river, exceeding $100 000 000 in value, would be safe.

Storage Reservoir Sites.—A comprehensive plan for the development of the water resources of the Colorado River Basin will undoubtedly call for the utilization of most of the reservoir sites mentioned in Table 1. The locations of these sites are shown on Fig. 1.

Table 1.—Storage Reservoir Sites in the Colorado River Basin.

Name.	Stream.	Height of dam, in feet.*	Capacity, in acre-feet.
Flaming Gorge	Green River, Utah-Wyoming	255	4 720 000
Juniper Canyon	Yampa River, Colorado	200	1 400 000
Ouray	Green River, Utah	300	28 000 000
Kremmling	Grand River, Colorado	230	2 200 000
Dewey	Grand River, Utah	213	2 500 000
Green-Grand	Junction of Green and Grand Rivers, Utah	270	8 600 000
Bluff	San Juan River, Utah	264	2 600 000
Lee Ferry	Colorado and San Juan Rivers, Utah-Arizona	700	50 000 000†
Boulder Canyon	Colorado River, Nevada-Arizona	600	31 600 000

* The figures in this column indicate the elevation of spillway above river bed.
† Estimated.

These storage sites and their use were discussed in the writer's report on the "Colorado River and Its Utilization".* An analysis was made of the

* *Water Supply Paper No. 395,* U. S. Geological Survey, 1916.

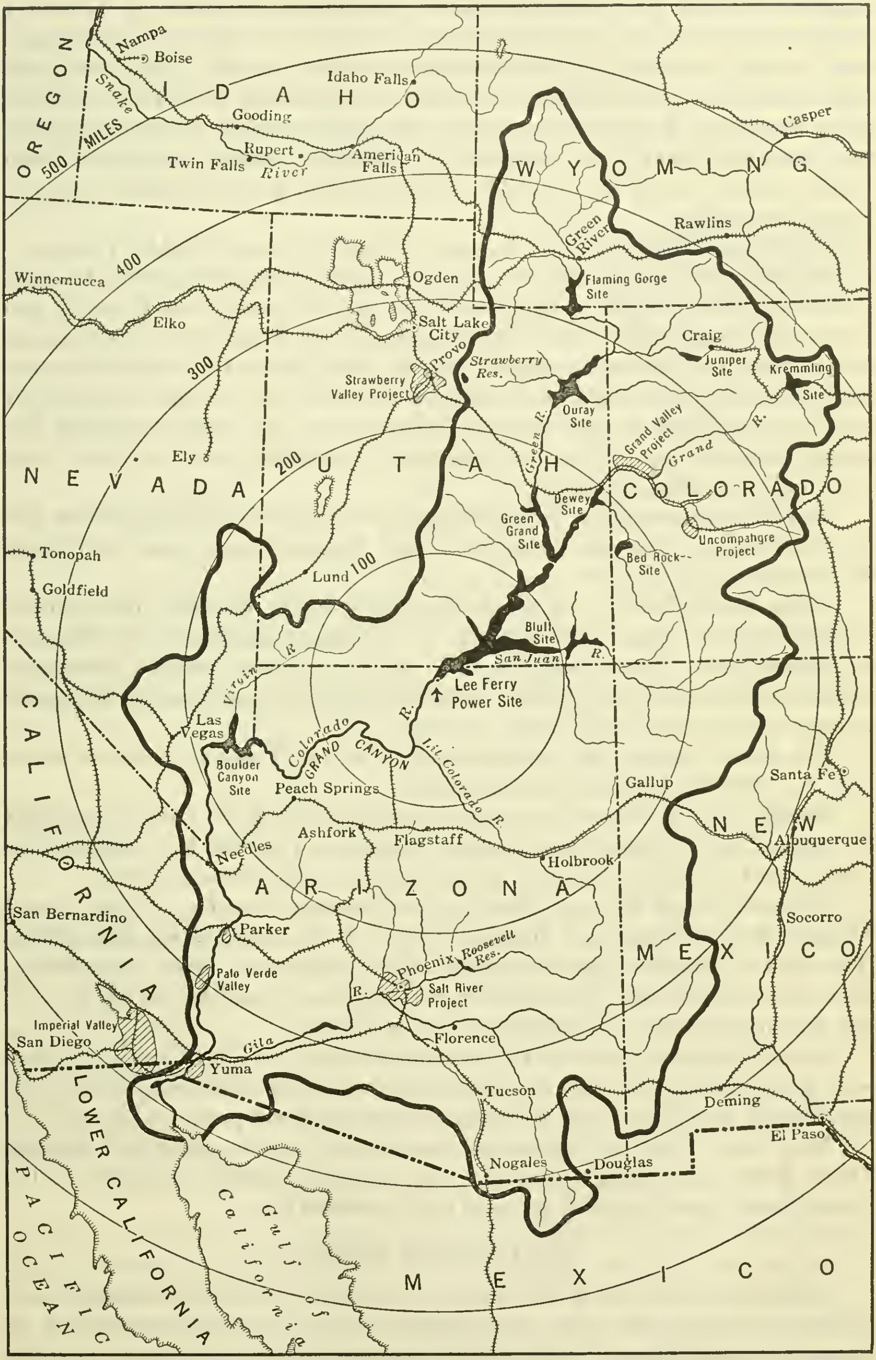
OREGON
IDAHO
WYOMING
NEVADA
UTAH
COLORADO
ARIZONA
NEW MEXICO
CALIFORNIA
LOWER CALIFORNIA
PACIFIC OCEAN
Gulf of California
MEXICO
500 MILES
400
300
200
100
Nampa
Boise
Snake River
Idaho Falls
Gooding
Rupert
American Falls
Twin Falls
Casper
Rawlins
Green River
Flaming Gorge Site
Winnemucca
Ogden
Elko
Salt Lake City
Provo
Strawberry Res.
Strawberry Valley Project
Craig
Juniper Site
Kremmling Site
Ouray Site
Green R.
Grand Valley Project
Grand R.
Ely
Dewey Site
Green Grand Site
Uncompahgre Project
Tonopah
Goldfield
Lund
Bed Rock Site
Bluff Site
San Juan R.
Lee Ferry Power Site
Virgin R.
Las Vegas
Colorado R.
Grand Canyon
Lit. Colorado R.
Boulder Canyon Site
Peach Springs
Gallup
Santa Fe
Ashfork
Flagstaff
Albuquerque
Needles
Holbrook
San Bernardino
Parker
Socorro
Palo Verde Valley
Phoenix
Roosevelt Res.
Salt River Project
Imperial Valley
San Diego
Gila
Yuma
Florence
Tucson
Deming
El Paso
Nogales
Douglas

FIG. 1.

records of stream flow, and mass curves indicated that the flow of the Lower Colorado could be equalized if properly located reservoir sites having an aggregate storage capacity of 25 000 000 acre-ft. were utilized. This study also indicated that, if no allowance is made for evaporation from the surface of these reservoirs, a uniform flow of 21 800 sec-ft. could be maintained below the San Juan River. The irrigation of additional lands in the Upper Basin would further reduce the quantity for the uniform flow that might be maintained by storage.

Undeveloped Water Power Between Green River and Boulder Canyon.—In the 670 miles between the Town of Green River, Utah, and Boulder Canyon, Nevada-Arizona, the fall is about 3 350 ft. As this part of the Colorado and that part of Grand River below the elevation of the Town of Green River are in practically a continuous canyon, the use of the water for irrigation within this stretch is impossible; but conditions are favorable for the regulation of flow by storage and for the development of power. The entire regulated flow might profitably be used for the irrigation of extensive areas of arable land situated below Boulder Canyon.

The data now available indicate that the water-power resources of the 670 miles of the river between Green River and Boulder Canyon, may be utilized by developing five projects.

Green-Grand Project.—A 170-ft. dam built on the Colorado River immediately below the mouth of Green River would make possible the development of 110 000 h. p. The capacity of this project for power may be greatly increased when the flow of the Green and Grand Rivers is regulated by additional storage in the upper basin of these streams.

Lee Ferry Project.—By building a dam at Lee Ferry to raise the water 700 ft., 1 000 000 h. p. may be developed.

Marble Canyon Project.—Assuming that the flow of the river is regulated by storage above, it may prove feasible to develop 1 380 000 h. p. between Lee Ferry and the western boundary of the Grand Canyon National Park.

Diamond Creek Project.—Between the western boundary of the Grand Canyon National Park and Diamond Creek, the Colorado River falls 500 ft. This part of the river may be developed by building two dams, each dam to raise the water 250 ft. The capacity of this project would be 830 000 h. p., if the flow of the river is regulated by storage above.

Boulder Canyon Project.—It is assumed that at Boulder Canyon the flow will be re-regulated to meet the demand for water for irrigation. Under this condition, a dam 550 ft. high will make possible the development of 700 000 h. p.

More than 4 000 000 continuous horse-power may be developed between Green River and Boulder Canyon. The aggregate installed capacity of the power plants would probably be more than 5 000 000 h. p.

The Lee Ferry Project

Eight miles above Lee Ferry, Ariz., is a site which has been selected as particularly favorable for both the regulation of flow and the development of power, the possibilities of which will be disclosed by the surveys and investigations now in progress.

Fig. 1 shows the general location of the Lee Ferry project and Figs. 2 and 3 show tentative plans for the storage dam, alternate spillway sites, and the position of the power tunnels and power house. The contours (Fig. 2) were sketched in and are intended only to show roughly the surrounding topography. A careful survey will probably show more favorable conditions. The physical features are shown clearly in Figs. 4, 5, 6 and 7. The views can

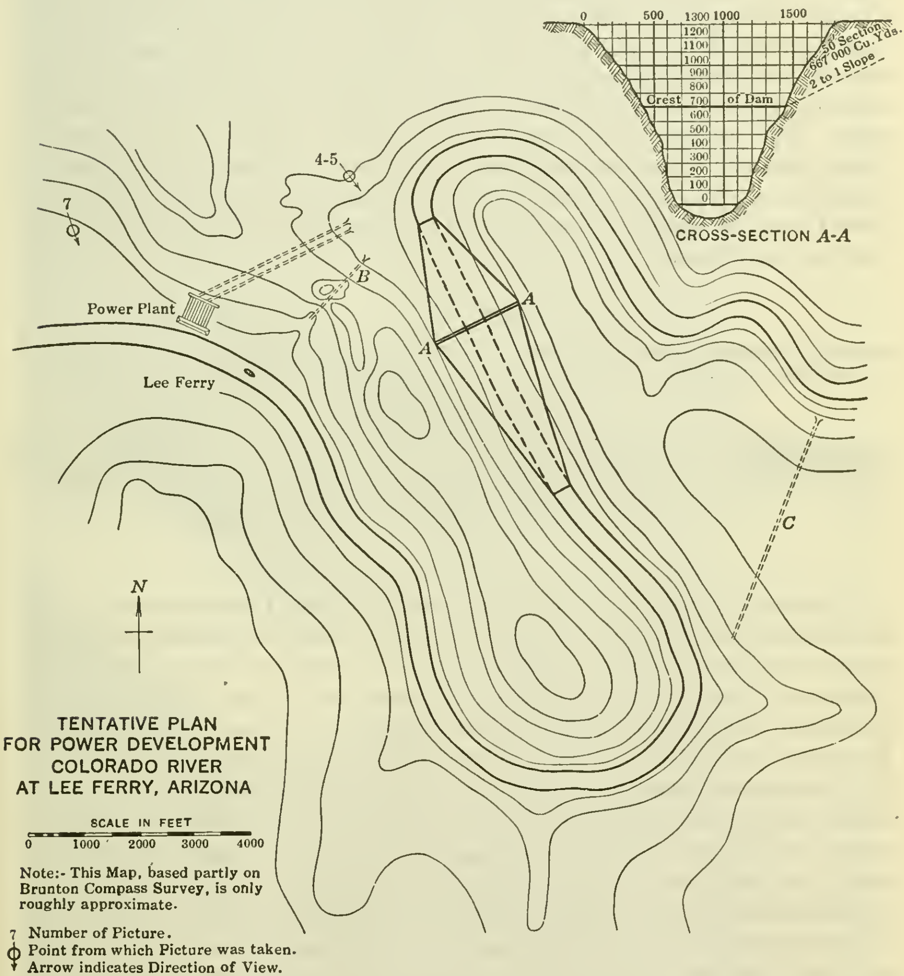

FIG. 2.

be better understood by referring to Fig. 2, on which is shown the number of the photograph, the point from which it was taken, and an arrow indicating the direction of view.

Present information indicates that to construct a 780-ft. dam at the Lee Ferry site may prove feasible. A dam of this height would form a reservoir with a capacity of about 50 000 000 acre-ft. The maximum back-water would

extend up stream nearly to the junction of the Green and Grand Rivers and to within 230 ft. of the elevation of the piers of the railroad bridge near Green River, Utah.

The capacity of the upper 100 ft. of the Lee Ferry Reservoir would be about 20 000 000 acre-ft. Allowing for evaporation from the reservoirs and for the use of water in the upper basin for the irrigation of additional lands, the 20 000 000 acre-ft. of storage capacity may be sufficient to equalize the flow through the canyons of the lower river. With a 100-ft. drawdown, the average head available at Lee Ferry for power would be about 650 ft., and with the flow of the river equalized at this point, power plants in the canyon below could be operated under heads almost equal to the full height of the respective dams. The dam farthest down stream, however, should provide sufficient storage capacity to regulate the flow to conform to the demand for irrigation. Under these conditions, it seems probable that an aggregate effective head of 2 800 ft. may be utilized out of the 3 350 ft. of fall between Green River, Utah, and Boulder Canyon.

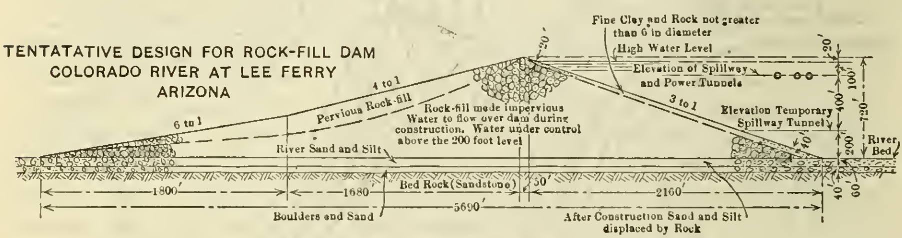

FIG. 3.

The mean annual flow at Lee Ferry has been about 15 000 000 acre-ft., but allowing for the reduction in flow for ultimate irrigation development in the upper basin, this quantity may be reduced to 10 000 000 acre-ft. It may be fifty years before ultimate irrigation development in the upper basin is reached. To assume that a uniform flow of about 19 300 sec-ft. can be maintained at the Lee Ferry site and in the canyons below would seem reasonable.

The depth to bed-rock at the dam site has not been determined, but the writer believes that rock is near the surface in the river channel. When he examined this part of the river in August, 1915, the river was at a very low stage, and down stream about 8 miles from the Lee Ferry dam site, the bed-rock appeared to extend across the channel of the Colorado River at the surface.

At the dam site the red sandstone walls of the canyon rise 1 300 ft. above the river, and the width of the canyon at the water surface is 450 ft. The course of the river at this point is in the form of the letter "S", thus making two spillway sites available. By constructing tunnels through the bluff, the water may be carried about 3 000 ft. to a forebay and power house which is 6 miles by river from the dam site. The site is easily accessible by automobile and a railroad could be built at a comparatively low cost, connecting with the nearest railroad point, Flagstaff, Ariz., 133 miles to the south. After considering the conditions at the dam site, the facilities for spillways, site for

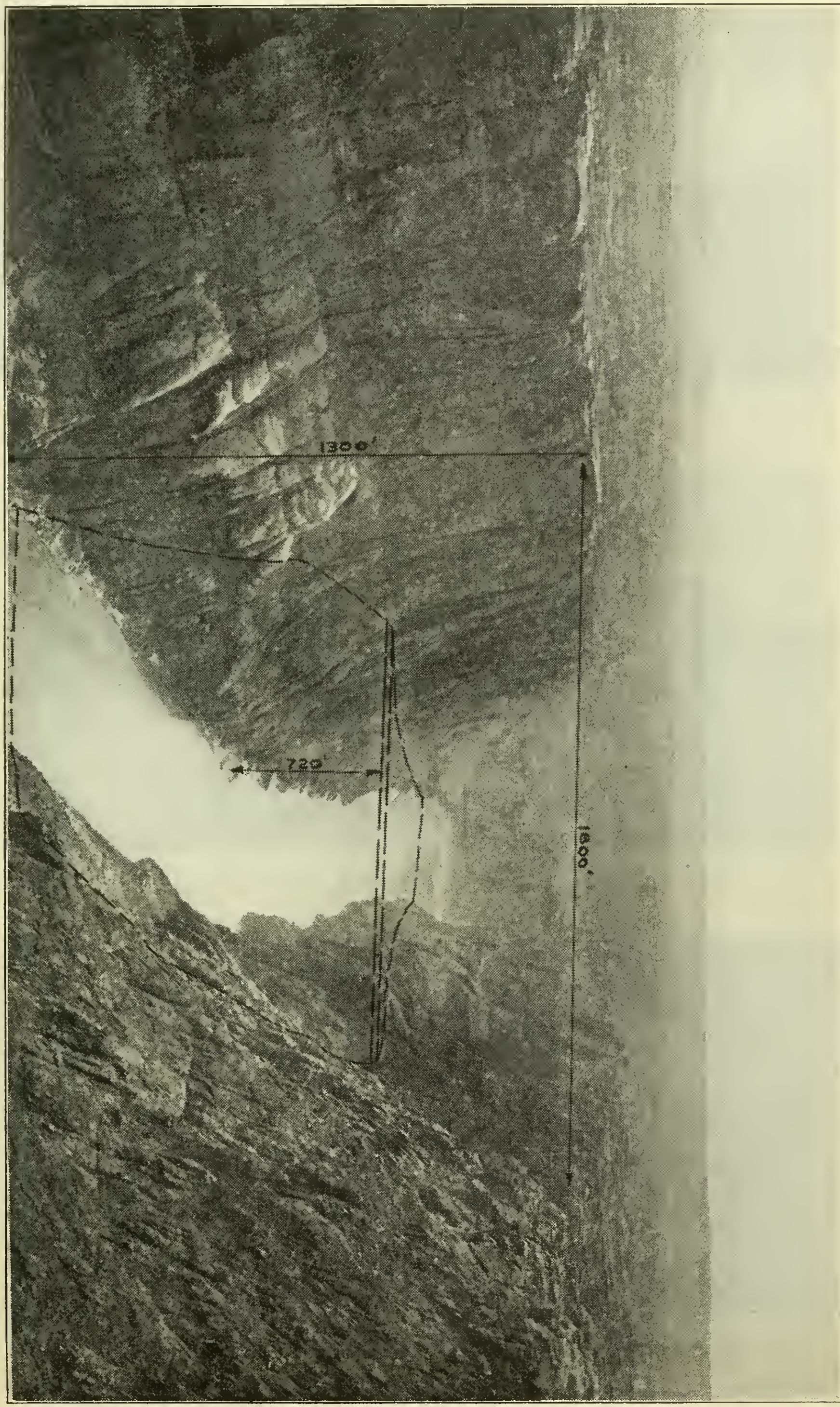

FIG. 4.—DOWN-STREAM VIEW OF DAM SITE AT LEE FERRY, ARIZ.

FIG. 5.—PANORAMIC VIEW, LEE FERRY, ARIZ.

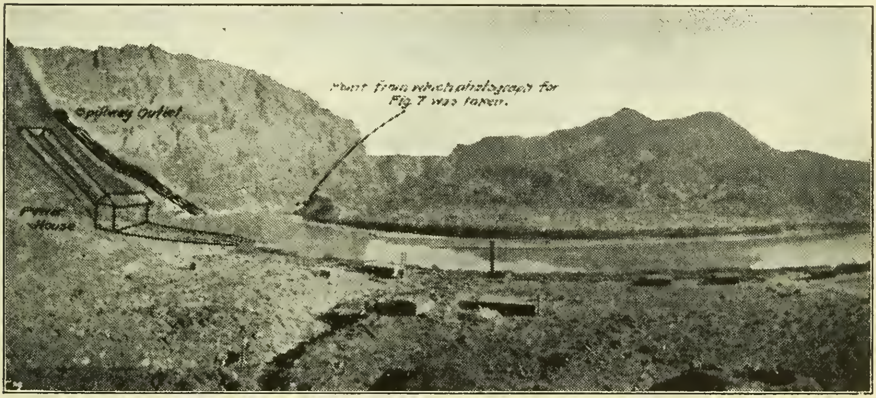

FIG. 6.—UP-STREAM VIEW, 1 MILE BELOW DAM, LEE FERRY, ARIZ.

FIG. 7.—VIEW SHOWING SITE OF POWER HOUSE, ETC., LEE FERRY, ARIZ.

power house and auxiliary structures, storage capacity above the dam, and the accessibility of the project, the writer believes the Lee Ferry site to be one of the most promising on the Colorado River below the junction of the Green and Grand Rivers.

Should this project be developed, water would be available for irrigation on the lower river for at least a generation to come, and the menace from floods would be removed (except floods from the Gila River).

The conditions favor the construction of a 780-ft. dam of the rock-fill type. (Fig. 3.) Although such a high rock-fill dam has never been constructed, the writer believes that one can be built at this site and made practically water-tight at a much less cost than any other type of dam.

Tentative Design for Rock-Fill Dam.—In designing a rock-fill dam for the Lee Ferry site a slope of 3:1 was used for the up-stream face, for the down-stream face 6:1 was used to the 300-ft. level, and 4:1 for the remainder. (Fig. 3.) The rock for the dam can be blasted from the canyon walls. With this plan of construction the slopes of the finished dam would be uneven, but the writer believes that the general slope of both faces of the finished dam should not be greater than those mentioned.

It is assumed that bed-rock lies at a depth of 100 ft. below the bed of the river, that the channel is filled with fine sand and silt to a depth of 60 ft., and that the next 40 ft. is composed of sand and boulders. If the canyon walls were blasted into the river, the heavy mass of material would settle to the level of the boulders assumed to be 60 ft. below the bed of the river, and some of the fine sand and silt would be forced up. Under these conditions, the finished dam would contain 50 000 000 cu. yd. of material. The center 50-ft. section of the dam would contain about 1 000 000 cu. yd.

Prior to construction, the outline for the dam could be plainly marked on the canyon walls. (Fig. 4.) A plan for mining both walls of the canyon could be worked out from detailed topography of the site of the dam. To obtain 500 000 cu. yd. of rock from each wall for the center 50-ft. section of the dam, it would be necessary to blast the walls back on a slope slightly steeper than 2:1 (Fig. 2), and, here, it may be necessary to rehandle some of the material. Up and down stream from the center 50-ft. section of the dam, the walls of the canyon may be blasted from a lower level, and the required quantity of material obtained by blasting back on a much steeper slope. The space occupied by the loose rock in the dam will be about 15% greater than the space occupied by the same material in its natural compact state. If the mines are properly placed in both walls of the canyon, the first shots will blow enough rock into the river to form a dam 250 ft. high, having a gradual slope to the lower toe, more than a mile down stream.

The discharge of the river may be expected to range from 4 000 to 10 000 sec-ft. during the eight months following the flood period. Perhaps 50% of the material in the dam would consist of rock weighing from 1 ton to 1 000 tons. If the unexpected should happen, and a flood of 100 000 sec-ft. should pass over the unfinished dam, some of the material might be moved down stream. The unfinished dam would have a slope of about 5% and the bed over which the flood would pass would be rough. Under these conditions, the water,

8 ft. in depth, might attain a velocity of 30 ft. per sec. Since weight of bodies that can be moved by a current varies as the sixth power of the velocity, such a flood would have an enormous ability for destruction. The lighter materials would be carried down stream; and rock that could withstand the force of the water would settle. However, floods which occur outside the normal flood period, last only a few days. To believe that after the flood, the unfinished dam would retain a height of 100 ft. or more above the average low-water level seems more reasonable than that all of it would be carried away. Such a flood might prove to be a blessing in disguise, since that part of the dam remaining would form a solid foundation on which to build the superstructure.

However, flood water should not be permitted to flow over the dam, and it is suggested that no material be blasted into the river until a temporary spillway has been provided 200 ft. above the bed of the river. A spillway tunnel located at *B* (Fig. 2), would be about 3 000 ft. long and could be given a fall of 200 ft. A spillway tunnel, 30 ft. in diameter, with a properly designed entrance, would have approximately the following capacity:

Elevation of water above gate-sill, in feet.	Capacity, in second-feet.
0	0
10	5 000
20	13 500
30	22 500
40	28 500
50	33 700
60	38 200
70	42 000
80	45 000
90	47 400
100	50 000

With the spillway completed and the flood stage passed, the mines may be discharged and about 20 000 000 cu. yd. of rock would be blown into the river. This mass of loose rock would not be water-tight which feature is the most uncertain in the plan here presented.

This mass of rock, weighing about 40 000 000 tons, would displace the fine sand and silt and would tend to form a mud bank immediately up stream from the dam. Such a mud bank would be practically water-tight and, until overtopped, it would cut off the flow of the river. This material might make the rock-fill water-tight to an elevation of 50 to 100 ft. above the bed of the river, and thus form a reservoir having a storage capacity of from 100 000 to 700 000 acre-ft. If the flow of the river was 5 000 sec-ft., the supply of water for irrigation might be cut off for a period of from 10 to 70 days.

Water for the irrigation of more than 400 000 acres of land on the Lower Colorado must be available each month of the year. To cut off the supply of water for the irrigation of these lands, even for a 10-day period, might result

in serious damage to crops. An understanding should be had with the irrigation interests in order that they may take proper steps to protect the crops, should the supply of water be cut off.

Therefore, unless a temporary spillway is provided at an elevation of 50 ft. above low water, it will be necessary to discharge the mines when the river is in flood so that the storage reservoir above the dam may be quickly filled, and permit the water to flow either through the upper part of the unfinished dam or through a temporary spillway located at the 200-ft. level. The writer believes that the temporary spillway should be located at the 200-ft. level and that the mines should be discharged after the peak of the summer flood, when the discharge has fallen to about 50 000 sec-ft. This feature of the project deserves consideration, and a thorough study of the stream-flow records should be made to determine the proper time for the first discharge of the mines.

Practically all the rock-fill can be blasted into place, thus making it unnecessary to rehandle the material except for finishing a small section at the top of the dam. The 50 000 000 cu. yd. of rock could probably be blasted into place at a cost of 10 cents or less per cubic yard. To determine the quantity of fine material necessary to make the rock-fill water-tight would be difficult, but the writer believes that about 10 000 000 cu. yd. of fine rock, sand, and silt would be required.

The upper face of the dam would be permanently submerged to the 600-ft. level, and, therefore, below this level no protection against wave action is necessary. The water in the reservoir would fluctuate between the 600 and 700-ft. levels. The reservoir would be located in a deep box canyon the circuitous course of which would prevent excessive wave action. (Fig. 3.) On the upper face of the dam, above the 600-ft. level, rock 2 ft. in diameter should probably be placed. This section will be wet and dry periodically and will require care in its construction, if the back-fill is to be kept water-tight.

Making the Rock-Fill Water-Tight.—Several methods have been used in the past to make rock-fill dams water-tight, but most of these methods appear unsatisfactory when applied to such a high dam.

A concrete core wall extending to bed-rock, is often used. If this plan were adopted at the Lee Ferry dam site, it would be necessary to excavate the river channel to bed-rock. To take care of the flood water during the period when the core wall is being built from bed-rock to the former water surface, would be both hazardous and expensive. For such a high dam there would be danger of the core wall becoming fractured on account of uneven forces being exerted by the rock-fill.

A steel core, having a concrete base, would be even more objectionable than a concrete core, for besides requiring a concrete facing to prolong its life, it would have all the objectionable features of the concrete core.

The rock-fill might be made water-tight by lining the up-stream face of the dam with concrete, but it would be necessary either to carry this concrete facing to bed-rock or to provide an impervious base for the dam with a series of cut-off walls. Otherwise, the water would pass under the concrete facing and undermine the dam. In addition to these objectionable features, the set-

tlement of the rock-fill would make it almost impossible to prevent the concrete facing from becoming fractured.

The writer believes that with the river under control the rock-fill can be made water-tight by sluicing fine material into the dam.

The discharge of the river ranges from 4 000 to 10 000 sec-ft. after the flood period. This quantity of water might find its way through the rock-fill. At this stage of construction, every attention should be given to the work of making the rock-fill water-tight. It would be necessary to place fine material on the upper face and perhaps as far down stream as the center of the finished dam. This material should be graded in size from that which would pass through a 1-in. to a 6-in. mesh. On the right bank of the river, a few hundred feet up stream from the upper toe of the dam, there is a talus which could be moved to the dam at a low cost. The back-water above the dam might have a depth of from 75 to 100 ft. and would extend up the river a distance of at least 25 miles.

Assuming that the rock-fill rises 250 ft. above the bed of the river, and that there is 100 ft. of water above the dam, the flow of water through the dam would be as follows: The water would rush through the open spaces between the large rocks, flow through the spaces between the smaller rocks, percolate through the sand, and seep through the clay or fine silt. The rush of water through the spaces between the large rocks would be partly stopped by the coarser material, that is, the rock 6 in. in diameter; and the flow through the spaces between the smaller rocks would be partly stopped by the finer material, that is, rock that would pass the 1, 2, 3, or 4-in. mesh. Large quantities of sand may then be deposited on the upper face of the dam. Due to the flow of water under high pressure, this sand would be carried into the dam. The deposit of fine clay or silt on the up-stream face and on top of the dam should produce a practically water-tight structure. Owing to the enormous pressure, water would always seep through the dam, but probably not in quantities sufficient to cause erosion.

When, in 1915, the writer made a trip by boat through 150 miles of the canyon of the Colorado River between Hite, Utah, and Lee Ferry, Ariz., large silt deposits at the mouth of Navajo Creek were observed. This creek joins the Colorado from the south, at a point about 18 miles up stream from the site of the Lee Ferry dam. Large silt deposits also were observed at many other points in the canyon below the mouth of San Juan River. These deposits could be located before they are covered with the back-water, and as the water reached the respective deposits, the material could be loaded on barges by dipper or suction dredgers. It might prove more economical, however, to place rock crushers on the plateau above the dam and transport the crushed material to the dam by chutes. It is thus seen that there is plenty of accessible material for use in the final process of making the rock-fill water-tight.

When the rock-fill becomes water-tight and the reservoir fills, the water may percolate through the 40-ft. layer of sand and boulders. (Fig. 3.) This water would be forced to travel a distance of about 5 700 ft. The indicated hydraulic gradient is about 1 : 8, and the writer believes that the frictional

resistance to the passage of water through the 40-ft. layer of sand and boulders would be sufficient to consume the head of 700 ft. before the lower toe of the dam is reached, in which case, the velocity of the percolating water near the lower toe of the dam would not erode the foundation. Under these conditions, the dam as designed would be safe against blow-outs caused by the upward hydrostatic pressure of the percolating water on the base of the dam.

It is said that the silt-laden waters of the Colorado would be sufficient to tighten the dam. This silt, however, would be deposited at the head of the back-water and not at the dam, which condition favors the completed project. With reservoir full, the back-water would extend up every side canyon and tributary of the Colorado, and would probably extend up the San Juan River, a distance of 80 miles or more. The San Juan, which carries a large quantity of silt would have its own stilling basin and, perhaps, 100 years would pass before the silt would reach the canyon of the Colorado. As each side canyon would have its own stilling basin, the water in the main canyon of the Colorado above the dam would remain practically clear. This is important when it is considered that the water is to be used for the development of power.

Since it is proposed to blast about 20 000 000 cu. yd. of rock into the river channel with the first discharge of the mines, arch action may result when this enormous quantity of material falls into the canyon, thus leaving a large open space within the proposed dam. Although such arch action is only a remote possibility, it might be advisable to discharge the mines in both walls of the canyon at the same instant, so that much of the material may meet over the river channel and fall vertically. Perhaps better results can be obtained by discharging the mines in one wall, after those in the other wall, but the writer believes it is impossible to determine just how the rock will fall when the mines are discharged.

Care of Water During Construction.—The writer believes it unnecessary to have the river under control until the dam is raised to an elevation 250 ft. or more above the bed of the river. If the mines were discharged immediately after the flood period has passed, at least eight months would elapse under normal conditions before the river would again be at flood stage. During these eight months, it is expected that the upper face of the dam can be raised 100 ft., or to an elevation of 350 ft. above the bed of the river. The storage capacity of the reservoir between an elevation of 200 and 350 ft. is about 8 000 000 acre-ft.

The writer has described* the flood of 1917, during which the peak at Lee Ferry was about 147 000 sec-ft., one of the highest floods of record originating above that site. An analysis of the records of daily discharge for this flood period shows that the water level in the Lee Ferry Reservoir would have been raised from an elevation of 215 ft. to an elevation of 332 ft. above the bed of the river. The accumulated storage above the 200-ft. level would have been about 7 300 000 acre-ft. and the total volume discharged through the temporary spillway would have been nearly 7 500 000 acre-ft. It is seen, therefore, that in order to prevent such a flood overtopping the unfinished

* *Engineering News-Record,* March 6th, 1919.

dam, it would have been necessary to raise the dam at least 332 ft. above the bed of the river. For the plan of construction herein presented, the writer believes that the most dangerous period would be that during which the dam is being raised from the 200 to 350-ft. level. During this period, it may be necessary to take care of a summer flood such as that which occurred in 1917.

The water level in the reservoir during construction might be controlled most economically and efficiently by constructing only one temporary spillway, at the 200-ft. level, controlled by a Johnson valve having a capacity of 60 000 sec-ft. under a static head of 100 ft. As this spillway is to be used only during construction, it would not be necessary to provide slide-gates so that the Johnson valve may be unwatered for inspection and repairs. If a summer flood, such as that which occurred in 1917, must be taken care of when the dam is nearing the 300-ft. level, the temporary spillway will be taxed to its maximum capacity of 60 000 sec-ft. As the dam is raised above the 300-ft. level, the storage capacity of the reservoir becomes much greater, so that a spillway capacity of less than 60 000 sec-ft. would be required. Under this plan, the dam could be built to its full height without fear of its being overtopped by a flood during construction.

The tunnels leading to the power house may be located at the 600-ft. level. (Fig. 3.) Since this paper deals primarily with the design of a rock-fill dam, no attempt will be made to determine the most feasible location for the power tunnels.

The summer floods are caused by the melting snows in Colorado, Utah, and Wyoming. From the records of precipitation, the volume of the coming summer flood can be determined with fair accuracy 60 days in advance. A permanent spillway should be provided at the 600-ft. level so that the water level in the reservoir may be drawn down to provide sufficient capacity to take care of a flood much greater than any heretofore recorded.

Those in charge of the operation of the reservoir would be more concerned with the volume of run-off than with the magnitude of the flood peak. The quantity of snow in the upper basin would indicate whether the expected run-off would be high, low, or average in volume. An extended period of high temperatures, accompanied by a warm rain or "chinook" wind, would cause a flood of great magnitude, but of short duration. It would be impossible to predict such conditions 60 days in advance, but a study of the run-off records for the past 20 years would afford a fairly accurate basis for a prediction as to the time the summer flood may be expected.

Power During Construction.—As coal is abundant within 15 miles from the site, a steam plant could be built to furnish power during construction. After the dam has been raised above the 200-ft. level and the water is passing through the temporary spillway, power may be had by constructing a hydro-electric plant at the outlet of this tunnel.

Conclusions

1.—At the site of the Lee Ferry Dam, the canyon is narrow and the red sandstone is of good quality. These conditions favor the construction of a

rock-fill dam. It seems probable that practically all of the 50 000 000 cu. yd. of rock for the fill can be blasted into place. However, it will be necessary, or at least advisable, to resort to the hand-and-derrick method in placing a part of the rock in the portion of the dam above the 600-ft. level. The slopes of the finished dam are not expected to conform exactly with those shown on Fig. 3, but it is the writer's opinion that the average slope should not be steeper.

2.—Owing to the favorable conditions at the site of the dam, the writer believes it entirely feasible to raise the dam to the 250-ft. level with the first discharge of the mines. The quantity of material required to form a dam 250 ft. high depends on the depth to the layer of boulders and the depth to bed-rock. It would be advisable, therefore, to test the river channel for bed-rock by diamond drill borings.

3.—It would not be necessary to by-pass the flood water until the dam has been raised to an elevation of 200 ft. above the bed of the river, except that provision must be made to meet the demand for water for irrigation.

4.—Provision should be made to control the water level in the reservoir above an elevation of 200 ft., in order to facilitate the sluicing of fine material into the rock-fill to make it water-tight.

5.—Flood water should not be permitted to overtop the dam after it has been built higher than 200 ft. above the river bed.

6.—A permanent spillway should be provided at the 600-ft. level.

7.—The raw materials necessary for the construction of rock-fill dam are conveniently situated.

8.—In this project, it is planned to do on a large scale what has often been successfully accomplished on a smaller scale. The writer believes the most uncertain feature of the project is the work of making the rock-fill water-tight. If the seepage through the dam is sufficient to cause erosion, it would not be very expensive, considering the magnitude of the project, to blast in the canyon walls and produce a 6:1 slope from the crest of the dam to the lower toe.

9.—The writer believes that a rock-fill dam properly constructed would be fully as safe as a concrete dam. To the design herein presented for a rock-fill dam, the unit stresses developed in the foundation and abutment walls are low and need be given minor consideration. This type of dam, however, may be subject to failure due to a blow-out which might be caused by the upward hydrostatic pressure of the water percolating under the foundation. The writer believes that the rock-fill dam described in this paper would be safe against blow-outs or erosion. Should erosion occur, no doubt the trouble could be remedied long before there was any real danger of the dam failing.

Should either the rock-fill or a concrete dam be overtopped by a flood, the damage might be sufficient to cause failure. A flood passing over the top of the rock-fill dam would cause at least a partial failure of the dam. The seriousness of the damage would depend on the magnitude and duration of the flood.

Because the capacity of the reservoir is enormous, it is a comparatively simple matter to provide adequate spillway capacity, and the chances of a dam being over-topped by a flood are remote.

10.—A concrete dam built at the Lee Ferry site to raise the water 700 ft. above the bed of the river would have a volume of about 5 400 000 cu. yd. and would probably cost, including spillway structures, about $50 000 000. It is difficult to estimate the cost of a dam of the rock-fill type, but a liberal estimate indicates that it would be little more than half that of the concrete dam.

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PAPERS AND DISCUSSIONS

SURGE TANKS

By B. F. Jakobsen,* Assoc. M. Am. Soc. C. E.

Synopsis

The distinction between surge tanks for acceleration and deceleration is shown, and likewise the distinction between the requirements for medium high-head plants and for high-head plants. Tests of the Kerckhoff surge tank are presented, and the computed values are shown to agree closely with the tests. The tests show the rapid dampening of the surge that took place. In the Appendices the mathematical formulas are developed.

Introduction

With the growth of the size of power plants has come the increasing length of closed conduits. Where these are used in conjunction with turbine installations, it becomes advisable, and in some cases necessary, to use surge tanks in order to prevent excessive water-hammer when the turbine rejects load.

In this type of power plant, it also becomes necessary to provide water storage near the plant, so that the load on the plant can be increased as fast as modern operation requires. A surge tank designed for this last condition will also relieve surges or prevent them from entering the long closed conduit.

General

A typical surge-tank installation. Fig. 1, shows the tank located at the lower end of a long closed conduit and at the top of the penstock. The object of the surge tank is to relieve surges which travel up the penstock when the turbine is rejecting load and to furnish water to the turbine when the load is

Note.—Written discussion will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

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increased, since the gradient of the long conduit seldom suffices to provide the maximum acceleration needed for satisfactory regulation and operation of the plant.

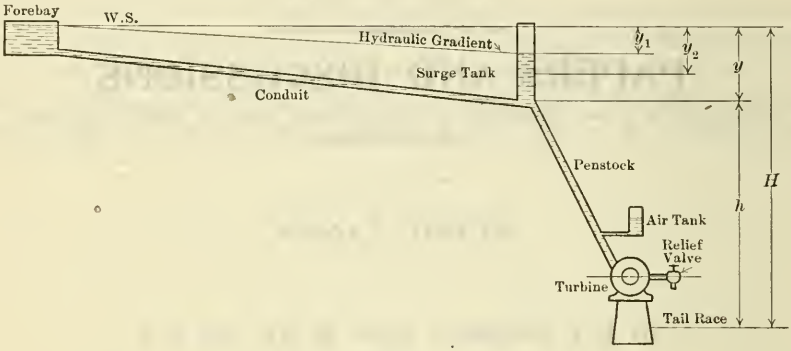

FIG. 1.

Surge tanks may be divided into two general classes, depending on the main object to be obtained:

I.—Surge tanks designed so as to allow the plant to take on load rapidly, and to spill on load rejection of no consequence.

II.—Surge tanks designed primarily to prevent spilling, on load rejection.

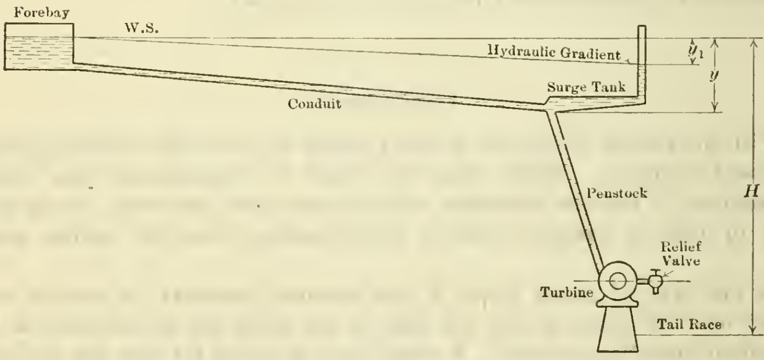

FIG. 2.

Case I.—Rapid Acceleration, as Shown in Fig. 2.—The water storage lies just above the lower end of the long closed conduit. With a certain load on the plant the drawdown is y_1 ft., as indicated. If the load is rapidly increased, the surge tank must supply the additional water, and the level of the water in the surge tank will be quickly lowered to the top of the storage chamber. In this design, the maximum accelerating head is made available for the long conduit practically from the start, and this, therefore, permits the use of the smallest possible surge tank. If, however, y is a considerable part of H, as it is likely to be with medium high-head plants having long conduits, the

head on the turbines is lowered at the time it is most needed, and the lowering of the head in the surge tank operates to decrease the total available output of the plant. To overcome this disadvantage, the storage must be somewhat distributed, as discussed subsequently.

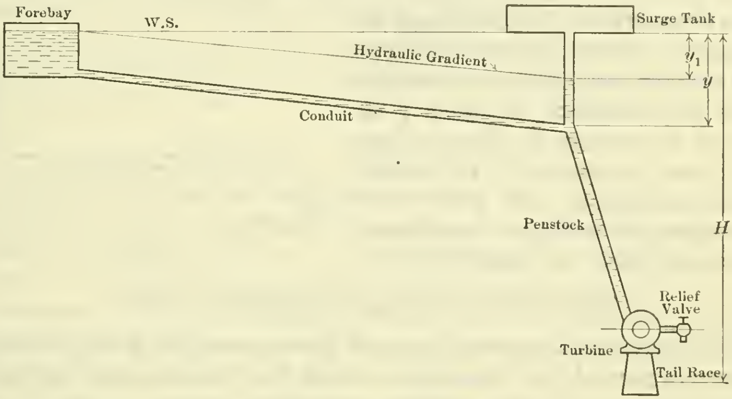

FIG. 3.

Case II.—Rapid Deceleration, as Shown in Fig. 3.—It is evident that with Case II, the storage should be placed as high as possible without additional cost, in order to reduce to the least possible its volume. The type of surge tank, shown in Fig. 3, will be only of small assistance to the plant when the load is increased. The combination of Fig. 2 and Fig. 3 would have the advantages of both, but the disadvantage, due to the lowering of the head on the turbine when the load is increased, will still remain. With medium high-head plants, or where y, Fig. 1, is a considerable part of H, it will generally be advisable to distribute the storage so that the two types of surge tanks develop the shapes shown in Fig. 4 and Fig. 5.

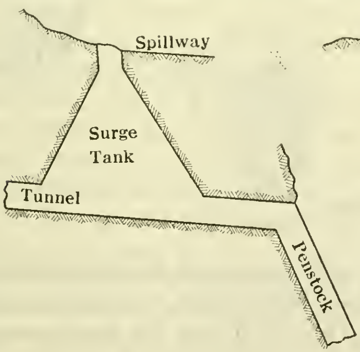

FIG. 4.

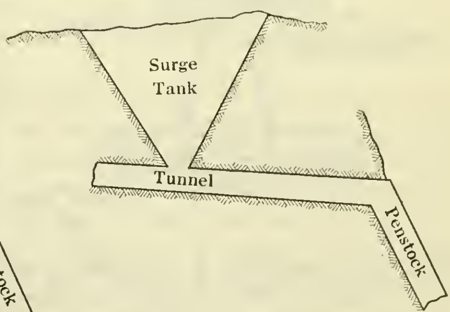

FIG. 5.

SURGE TANK FOR HIGH-HEAD PLANTS

With plants where y is a considerable part of H, the surge tank shown in Fig. 2 will be the most advantageous. It may be a circular conduit, built slightly above the roof of the tunnel and inclined just enough to insure proper

operation. This conduit may be a short section of tunnel or of pipe. Fig. 6 shows a vertical section of such a surge tank, which tank was designed by the writer in connection with the plant of the Homestake Mining Company in South Dakota, and was built by F. G. Baum, M. Am. Soc. C. E., A. L. Wilcox, Assoc. M. Am. Soc. C. E., acting as Construction Engineer.

The computations for such a tank are comparatively simple, since it may be assumed that the water surface is instantly lowered and, therefore, the head, y operating on the water in the tunnel or long conduit may be assumed to be constant without introducing any great error. This assumption simplifies the computations, as indicated in Appendix II.

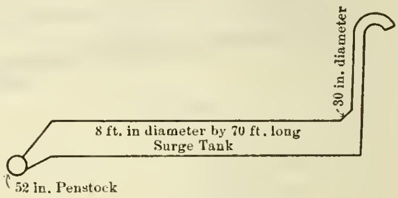

Fig. 6.

Surge Tank for Medium High-Head Plants

Fig. 4 represents the design proposed by the writer for plants where y is a considerable part of H. This shape of tank has the advantage that its area increases as the hydraulic gradient is lowered, that is, as the maximum accelerating head decreases, and a surge tank of this general shape, therefore, has its storage where it is most needed.

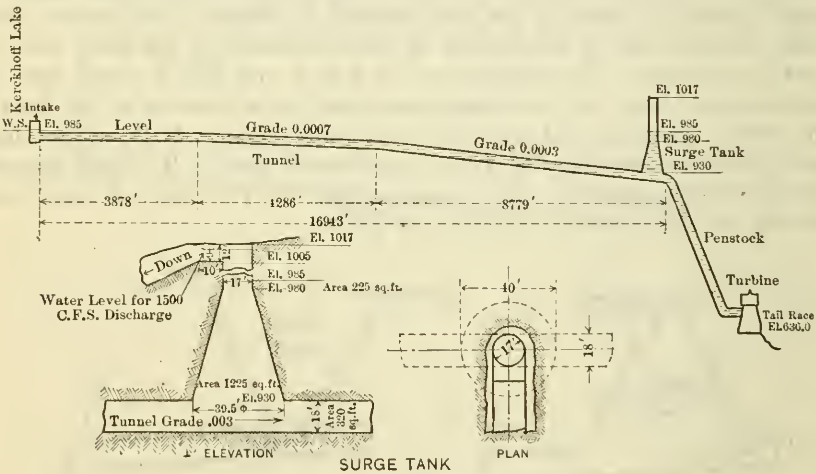

Fig. 7.

Where the surge tank is excavated in solid rock, as at the Kerckhoff Power Plant, the cost of excavating is practically independent of the shape of the tank, and one similar to that shown in Fig. 4 will give the least excavation and, therefore, the lowest cost. If the tank has to be built of reinforced concrete, the shape shown in Fig. 4 may cost more than that shown in Fig. 5 for equal volumes, and the problem is complicated by the additional fact that the shape of the tank influences its cost.

The Kerckhoff surge tank, shown on Fig. 7, is 17 ft. in diameter at the top and 39.5 ft. in diameter at the bottom. These dimensions were decided

on after a few trial computations with various assumed load changes, and after deciding, in consultation with the Operating Department, the extreme load change that the plant must meet. The writer knows of no general method of determining the most economical shape of tank. This will vary, with the assumed load change. The tank giving the smallest cost for the extreme load change it is able to take care of, will generally be the one to select. The smaller diameter should be selected so as to give satisfactory spilling conditions when load is rejected by the plant.

Kerckhoff Surge Tank Test

The Kerckhoff surge tank and the hydraulic data for the conduits are shown in Fig. 7. The tunnel, which is about 18 by 18 ft., with a slightly arched roof, has an average area of 320 sq. ft. The power plant has three turbines, each of 15 000 h. p. maximum rating at 315 ft. effective head, connected to 14 200-kv-a. generators. The three penstocks, which are 8 ft. in diameter at the top, tapering to 7 ft. at the bottom, average in length about 930 ft. This plant, built by the San Joaquin Light and Power Corporation, was put on the line in August, 1920. R. C. Starr, M. Am. Soc. C. E., is Construction Engineer, and the writer is Designing Engineer for the Company. L. O. Wolcott, Assoc. M. Am. Soc. C. E., made most of the computations for the surge tank.

To determine how closely the computations check with tests, several load-on and load-off tests were made on October 16th, 1921, under the general supervision of E. A. Quinn, General Superintendent of Operation.

It was intended to obtain the surge tank readings by means of a Bristol gauge which was connected to a bulb placed in the bottom of the surge tank, but, during the first test, the bulb broke and could not be replaced in time for the test. It was necessary, therefore, to measure the water surface in the surge tank by a float tied to the end of a steel tape. As one of the units was connected to the system of the Pacific Gas and Electric Company, the load on it could not be varied. The other two units were used in the test, the load being transferred as needed between the Kerckhoff plant and the steam plants at Bakersfield and Midway, Cal.

Two tests with load on and two tests with load off were made. During the second load-on test, the tape broke so that the data are not complete. Table 1 gives one test for load on, and Table 2, one test for load off. The wattmeters in the power house were read by the power-house crew, under the supervision of Mr. Goldsworthy, Superintendent of the Plant, and the surge tank readings were made by L. J. Moore, Executive Engineer. The load was transferred from or to the Kerckhoff power house as fast as possible without too great variations of the frequency of the system.

The readings of the elevation of the float in the surge tank were taken at intervals of 15 sec. and are shown on Fig. 8, on which is also plotted the load on the plant. The first small surge is probably due to the rapid increase of load in the beginning, followed by a less rapid increase. As noted in Table 1, the load on Generator No. 3 was read only at the beginning and at the end of the test. In plotting the load, it was assumed that this decreased roughly in the same proportion as the load on the other two

units increased. In order not unduly to complicate the check computations, which are plotted on Fig. 9, the load was assumed to increase uniformly from 9 000 to 27 850 kw. in 70 sec.

TABLE 1.—LOAD-ON TEST.

Time, in seconds.	LOAD ON GENERATORS, IN KILOWATTS.		
	No. 1.	No. 2.	No. 3.
0	0	0	9 000
15	1 000	2 500	No reading
30	4 000	6 500	" "
45	6 000	8 500	" "
60	10 000	8 000	" "
15	9 500	8 500	" "
30	10 500	9 700	" "
45	10 500	10 250	" "
120	9 600	10 250	8 000

TABLE 2.—LOAD-OFF TEST.

Time, in seconds.	LOAD ON GENERATORS, IN KILOWATTS.		
	No. 1	No. 2.	No. 3.
0	10 000	7 500	8 500
5	8 000	6 500	No reading
10	4 000	3 000	" "
15	500	0	" "
20	0	0	" "
0	0	0	8 500

The quantity of water was estimated as follows: With Generator No. 3 carrying 9 000 kw. and Generators Nos. 1 and 2 carrying no load, but operating at synchronous speed, the elevation of the water in the surge tank was 981.5 ft. and in the tail-race, 636.0 ft., thus giving an effective head of 345.5 ft. Fig. 10 shows that the water required at no load is about 16% of that required at full load, but 17% was assumed, to allow for water taken by the exciter, the load on which varied from 67 to 109 kw., and cooling water for the step-bearings and the transformers. The maximum load of one unit is approximately 18 700 h. p., so that the load required for one unit is about 3 180 h. p., or 162 cu. ft. per sec., for the two machines. The water required by Unit No. 3, carrying 9 000 kw. with a turbine efficiency of 96% and with a friction head of 5.0 ft. in the penstocks, was 374 cu. ft. per sec., so that the total water at the start was 536 cu. ft. per sec. Likewise, the water required at the close of the test, with 27 850 kw. on the plant and with the water in the surge tank at Elevation 970.2, was determined as 1 182 cu. ft. per sec. This quantity was incorrectly estimated as 1 145 cu. ft. per sec., and Fig. 9 was computed before the error was discovered, but as this error is only about 3%,

it was thought not worth while to re-compute this test, since the surge tank was excavated from solid rock, and its dimensions most likely vary more than 3 per cent.

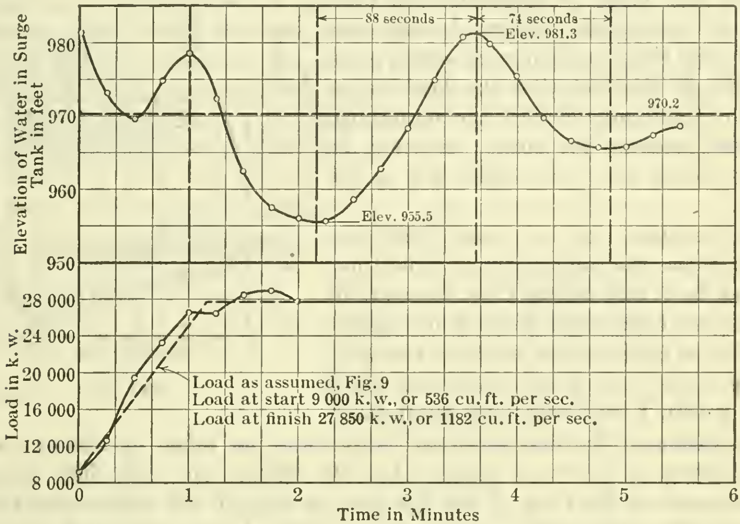

FIG. 8.

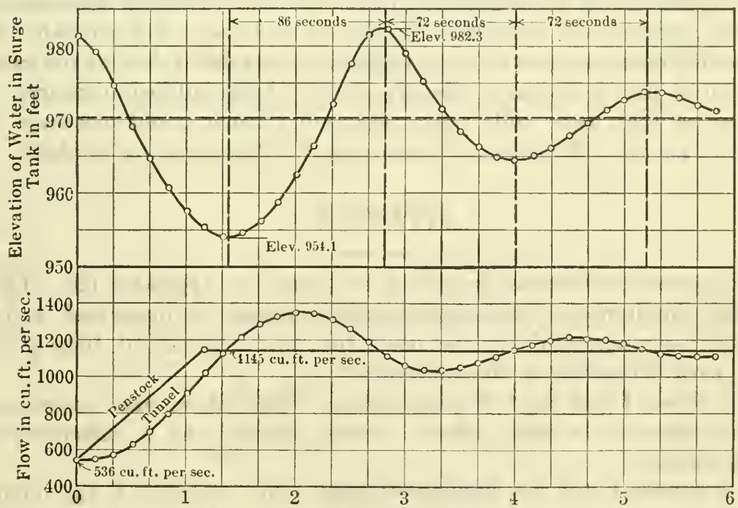

FIG. 9.

The friction loss in the tunnel was the difference in the elevations of the water in the surge tank and of Kerckhoff Lake which, throughout the test, was 984.2. For 536 cu. ft. per sec., the elevation of the water in the surge tank was 981.5, and for 1 145 cu. ft. per sec. (should have been 1 182 cu. ft. per

sec.), it was 970.2, thus indicating a friction loss in the tunnel of 2.7 ft. and 14 ft., respectively. This corresponds roughly to Kutter's $n = 0.032$. A comparison of Figs. 8 and 9 shows that the actual surge was slightly less than the computed surge, probably due to the fact that the load as assumed did not coincide with the actual load and, also, because the surge tank may be slightly larger than that called for in the design.

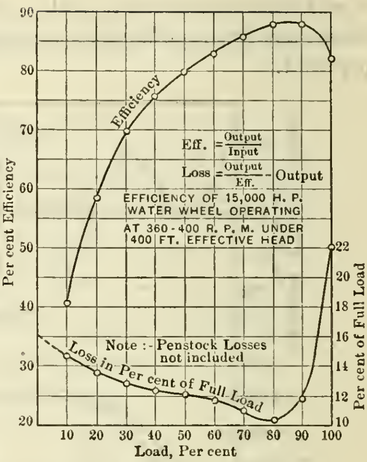

Fig. 10.

At the start, the load was 26 000 kw. Fig. 11 shows the computations. The time, as taken by a stop-watch, from the start of the test until the water reached its highest elevation at 1008.5, or 3.5 ft. above the spillway lip of the surge tank, was 25 sec., which agrees within 1 sec. with the computations. The elevation of the first downward surge was not taken on account of the rapid motion of the water surface, but Mr. Moore, who took these measurements, stated at the time of the test that he thought the water was at about Elevation 968, whereas the computations give 963. A measurement on the second downward surge was taken, but the time was not noted. The time from the second upward surge to the second downward surge was taken by a stop-watch as 60 sec., whereas the computations show 62 or 63 sec. The somewhat larger computed surges were due to the operation of the relief valves at the turbines. These valves have a discharge capacity of 50% of the full load discharge of the turbines, so that when fully open, each relief valve would discharge about 275 cu. ft. per sec. No means of measuring this discharge was available.

APPENDIX I

The general differential equations are given in Appendix III. The two resulting simultaneous differential equations cannot be integrated, and their use requires computations to be made for time intervals of from ½ sec. to 1 sec. apart, depending on the curvature.*

It is believed that the following method, which allows time intervals of 10 sec. and more to be used, offers a much simpler and a sufficiently close approximation.

It is assumed that for sufficiently small time intervals, t, the quantities involved are linear functions of t. The velocity head in the long conduit has been neglected, as in most cases it is small and the accuracy of the whole investigation depends on the friction loss in the tunnel which, in general, cannot be closely estimated beforehand. If, in order to be on the safe side, the friction loss in the tunnel is taken large enough, the velocity head may be assumed to be included in the friction head.

* "Water Power Engineering", by Daniel W. Mead, Appendix C.

The flow in the penstock may vary in any manner desired, so that, if desirable, the action of the governor may be included in the computations. In general, such a refinement is unnecessary since the assumed maximum load changes are determined approximately and are largely a matter of personal judgment. Also, most of the other quantities that influence the performance of the surge tank are not known accurately at the time the surge tank is designed. As a rule, it will be sufficiently accurate to assume the flow in the penstock as increasing uniformly from a starting value to the final value, but any assumption as to load variation may be made.

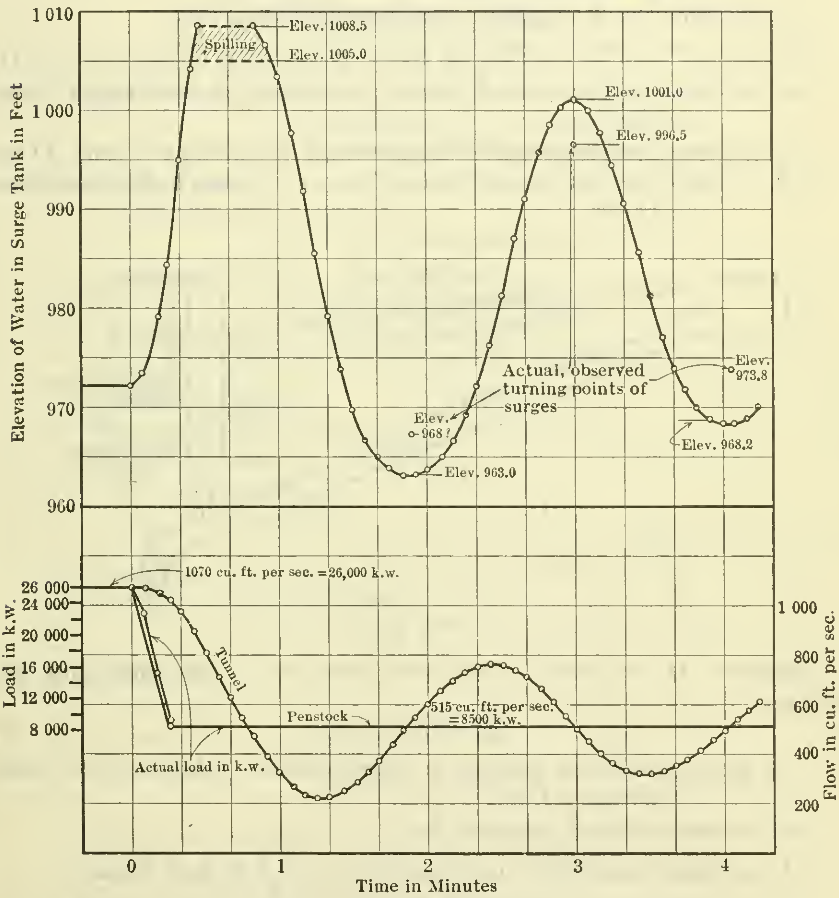

FIG. 11.

In surge-tank design the assumption is often made that the load change takes place instantaneously or during a very short interval. This is not generally correct, and the following formulas were developed for any load change. In the case of Kerckhoff surge tank, it was the opinion in the Operating Department that, in case of trouble, a certain part of the system load is lost and most of this comes back gradually within the next few minutes. The

surge tank was designed, therefore, for a uniform load change from no load (no cubic feet per second) to full load in 3 min. It was also computed for smaller instantaneous changes of load, such as, in the opinion of the members of the Operating Department, would or might occur.

SURGE TANK CALCULATIONS (FIG. 12).

Q_p = cubic feet flowing through penstock, in Δt sec., always $\overline{\gtrless}$ 0.

Q_t = cubic feet flowing through tunnel, in Δt sec., positive when flowing toward power plant.

Q_s = cubic feet flowing from or to surge tank, in Δt sec.

$$Q_s = Q_p - Q_t \qquad (1)$$

q_p = cubic feet per second flowing in penstock at beginning of time, Δt sec.

q_t = cubic feet per second flowing in tunnel at beginning of time, Δt sec.

q_s = cubic feet per second flowing from or to surge tank at beginning of Δt sec.

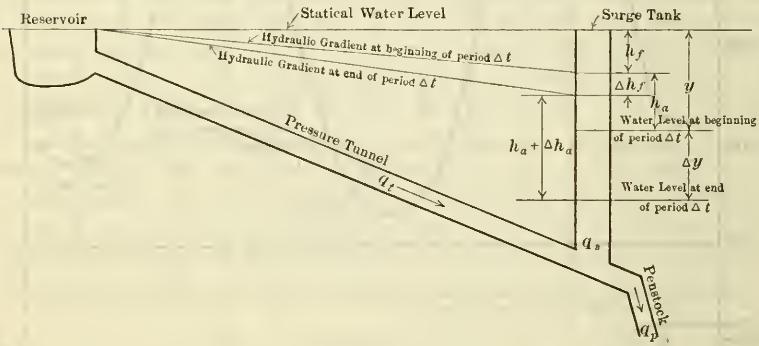

FIG. 12.

Therefore, Q_s is positive, when water flows out of the surge tank and *vice versa*.

$$q_s = q_p - q_t \qquad (2)$$

Δq_p, Δq_t, and Δq_s increase or decrease in the cubic feet per second during Δt sec.

A_t = area of tunnel, in square feet.

A_s = area of surge tank, in square feet, $y + \dfrac{\Delta y}{2}$ ft. from the top.

h_a = accelerating head acting on water in tunnel at beginning of Δt sec.

h_a is positive when the water in the tunnel is being accelerated while flowing toward the power plant.

Δh_a = increment of h_a during the time, Δt sec.

y = drawdown in surge tank at beginning of Δt sec., positive, when measured downward from zero position.

$y + \Delta y$ = drawdown at surge tank at end of time, Δt sec.

Therefore,

$$A_s \times \Delta y = Q_s \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

h_f = loss of head in tunnel due to friction and velocity heads, at beginning of time, Δt.

Δh_f = increment of h_f during time element, Δt.

$$y = h_a + h_f \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

a_i = acceleration of water in tunnel at beginning of time, Δt.

a_f = acceleration of water in tunnel at end of time, Δt.

a = average acceleration of water in tunnel during time interval, Δt.

g = 32.2 ft. per second per second.

L = length of tunnel from forebay to surge tank, in feet.

In the time Δt:

q_p becomes $q_p + \Delta q_p$, etc.

h_a becomes $h_a + \Delta h_a$, etc.

Friction Head.—

At beginning of time, Δt,

h_f corresponds to q_t.

At end of time, Δt,

$h_f + \Delta h_f$ corresponds to $q_t + \Delta q_t$.

Average value,

$h_f + 0.5\ \Delta h_f$ corresponds to $q_t + 0.5\ \Delta q_t$.

Accelerating Head.—

At beginning of period, Δt,

$$h_a = y - h_f.$$

At end of period, Δt,

$$h_a + \Delta h_a = y + \Delta y - h_f - \Delta h_f.$$

The average accelerating head, therefore, assuming that h_a, h_f, and y are linear functions for small values of Δt:

$$h_a + 0.5\ \Delta h_a = y - h_f + 0.5\ (\Delta y - \Delta h_f) \ldots\ldots\ldots (5)$$

Acceleration.—

$$\left.\begin{aligned} a_i &= \frac{d\,v}{d\,t} = \frac{h_a\,g}{L} \\ a_f &= (h_a + \Delta h_a)\frac{g}{L} \\ \text{average acceleration,}\quad a &= (h_a + 0.5\ \Delta h_a)\frac{g}{L} \end{aligned}\right\} \ldots\ldots\ldots\ldots (6)$$

Flow to or from Surge Tank, in Time, Δt.—

$$Q_s = \Delta y\, A_s = (\Delta h_a + \Delta h_f)\ A_s \text{ cu. ft.} \ldots\ldots\ldots\ldots (7)$$

Flow Through Tunnel, in Time Δt.—The increase of flow through the tunnel in time Δt, is:

$$\Delta q_t = a\ \Delta t \times A_t \text{ cu. ft. per sec., or,}$$

$$\Delta q_t = A_t\,(h_a + 0.5\ \Delta h_a)\,\frac{g}{L}\ \Delta t \text{ cu. ft. per sec} \ldots\ldots\ldots\ldots (8)$$

General Equations.—From Equation (1):

$Q_p = Q_t + Q_s$ cu. ft. flowing through the penstock, in Δt sec.

Assuming that the time interval, Δt, is chosen so small that the changes in q_p, q_t, and q_s, may be considered as linear, so that,

$$\left.\begin{aligned} Q_p &= \left(q_p + \frac{\Delta q_p}{2}\right)\Delta t \\ Q_t &= \left(q_t + \frac{\Delta q_t}{2}\right)\Delta t \\ Q_s &= \left(q_s + \frac{\Delta q_s}{2}\right)\Delta t \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Then,

$$Q_p = (q_p + 0.5\,\Delta q_p)\,\Delta t = (q_t + 0.5\,\Delta q_t)\,\Delta t + Q_s \text{ cu. ft.}$$

Substituting from Equation (8) for Δq_t and from Equation (7) for Q_s:

$$Q_p = q_t\,\Delta t + 0.5\,A_t\,(h_a + 0.5\,\Delta h_a)\,\frac{g}{L}\,\Delta t^2 + \Delta y\,A_s \text{ cu. ft.}$$

Since, from Equation (4):

$$\Delta y = \Delta h_a + \Delta h_f$$

$$Q_p = q_t\,\Delta t + 0.5\,A_t\,h_a\,\frac{g}{L}\,\Delta t^2 + 0.5\,A_t\,\frac{g}{L}\,\frac{\Delta h_a}{2}\,\Delta t^2 + A_s\,\Delta h_a + A_s\,\Delta h_f$$

$$Q_p = q_t\,\Delta t + 0.5\,A_t\,h_a\,\frac{g}{L}\,\Delta t^2 + A_s\,\Delta h_f + \Delta h_a\left(0.5\,A_t\,\frac{g}{L}\,\frac{\Delta t^2}{2} + A_s\right)$$

Arranging:

$$\Delta h_a = \frac{Q_p - q_t\,\Delta t - 0.5\,A_t\,g\,h_a\,\Delta t\,\frac{2}{L} - A_s\,\Delta h_f}{A_s + 0.25\,A_t\,g\,\Delta t\,\frac{2}{L}} \text{ ft.} \ldots\ldots (10)$$

and from Equation (8):

$$\Delta q_t = A_t\,(h_a + 0.5\,\Delta h_a)\,g\,\Delta\,\frac{t}{L} \text{ cu. ft. per sec.}$$

In Equation (10), the only unknown is $A_s \times \Delta h_f$; A_s is the average area of the surge tank at the water level during the period, Δt, or the arithmetical mean between the area of the water surface in the surge tank at the beginning and at the end of the period, Δt, and Δh_f is the increment of friction head during the time, Δt. In this case, A_s is considered to vary with y; if A_s is constant, the work is somewhat simplified. Since A_s is known for the beginning of each period, Δt, the average value may be closely approximated; likewise, since q_t is known at the beginning of each period, h_f is known, and, therefore, Δh_f can be closely approximated. Therefore, assuming values for A_s and for Δh_f, Equation (10) gives Δh_a and Equation (8) gives Δq_t; and q_t and Δq_t determine Δh_f, which should check with the value assumed for Δh_f. Since $\Delta y = \Delta h_a + \Delta h_f$, Δy can be determined, and since A_s depends on y and Δy, A_s can be determined, and this should check with the value assumed for A_s.

The manipulation of Equations (10) and (8) can be best shown by an example. Referring to the load-on test previously mentioned, Fig. 13 has been

plotted in order to have the values of A_s and h_f in a convenient form. The surge-tank area is plotted against the elevations and the tunnel friction loss against the cubic feet per second flowing in the tunnel. For Elevation 980, A_s is 225 sq. ft., and for Elevation 930, A_s is 1 225 sq. ft. Also, for

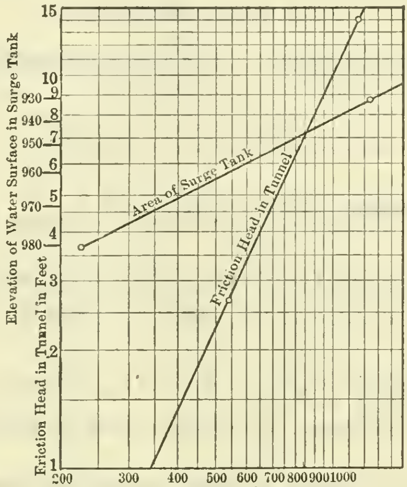

FIG. 13.

$q_t = 536$ cu. ft. per sec., the friction loss in the tunnel, h_f, is 2.7 ft., and for 1 145 cu. ft. per sec., it is 14 ft. $A_t = 320$ sq. ft., and length of tunnel, $L = 17\,000$ ft. The exact length of the tunnel is 16 943 ft., but 17 000 ft. was taken to allow for entrance losses, etc. The increase in q_p is from 536 to 1 145 cu. ft. per sec. in 70 sec., or 87 cu. ft. per sec. per each interval of 10 sec.

Introducing these constants, Equation (10) may be written:

$$\Delta h_a = \frac{Q_p - q_t \Delta t - 30.3 \, h_a}{A_s - 15} - \Delta h_f \text{ ft.}$$

Equation (8) becomes:

$$\Delta q_t = 6.06 \left(h_a + \frac{\Delta h_a}{2} \right) \text{ cu. ft. per sec.}$$

(1) $\Delta t = 10$ sec.;* $h_a = 0$; $h_f = 2.7$ ft.; $y = 2.7$ ft.

$$Q_p = 10 \left(536 + \frac{87}{2} \right) = 5\,795 \text{ cu. ft.}$$

Assume:

$$\Delta h_f = 0; \; A_s = 225 \text{ sq. ft.,}$$

then,

$$\Delta h_a = \frac{5\,795 - 5\,360}{210} = 2.08 \text{ ft.}$$

$$\Delta q_t = 6.06 \times 1.04 = 6 \text{ cu. ft. per sec.}$$

* A check computation with $\Delta t = 5$ sec. was made; this gave the same result as the computations made with $\Delta t = 10$ sec.

Therefore, $y = 2.7 + 2.08 = 4.8$ ft.; elevation of water surface in surge tank $= 984.28 - 4.8 = 979.4$ ft. The assumptions that $\Delta h_f = 0$ and $A_s = 225$, check (see Fig. 13).

$$(2)\ \Delta t = 10 \text{ sec.};\ h_a = 2.1 \text{ ft.};\ h_f = 2.7 \text{ ft.};\ y = 4.8 \text{ ft.}$$

$$q_t = 542 \text{ cu. ft. per sec.}$$

$$Q_p = 10\left(536 + 3 \times \frac{87}{2}\right) = 6\,660 \text{ cu. ft.}$$

Assume:

$$\Delta h_f = 0.2 \text{ ft.};\ A_s = 275 \text{ sq. ft.},$$

then,

$$\Delta h_a = \frac{6\,660 - 5\,420 - 30.3 \times 2.1}{260} - 0.2 = 4.34 \text{ ft.}$$

$$\Delta q_t = 6.06\ (2.1 + 2.2) = 25.4 \text{ cu. ft. per sec.}$$

Therefore, the assumed value of Δh_f checks (see Fig. 13).

Also,

$$y = h_a + \Delta h_a + h_f + \Delta h_f, \text{ or } 9.34 \text{ ft.}$$

The elevation of the water in the surge tank is 974.86 ft.; therefore, A_s checks.

It will be found convenient to make a table and enter the variables for each step. This also facilitates the plotting which should be done as soon as each step is completed in order to act as a check on the computations. Care is necessary in order to observe the correct signs of Δh_a and Δh_f. It is evident, from Fig. 9, that when the flow in the tunnel equals the flow in the penstock, the surge curve is a maximum or a minimum.

The operations are identical when load is decreased, except for change in signs. The load-off condition is, in general, of much less importance than the load-on condition.

In order to show the difference in drawdown between a surge tank, with a larger area toward the bottom, and one of equal volume, but with its larger area toward the top, computations were made by inverting the Kerckhoff surge tank, as shown in Fig. 14, and using the same load changes as shown in Fig. 9, in which the water surface fell to Elevation 954.1, where $A_s = 640$ sq. ft. This was assumed as the area at Elevation 981.5 in Fig. 14, and, therefore, the two surge tanks contain the same volume between Elevations 981.5 and 954.1. It will be seen that the drawdown of Fig. 14 amounts to 41.1 ft., whereas, in Fig. 9 it amounts to only 27.4 ft. This shows the advantage of having the larger area of the tank toward the bottom.

APPENDIX II

The computations for a surge tank, as shown in Fig. 2, are considerably simplified, because y may be assumed as constant and, therefore, Δy is zero.

Then, from Equation (4):

$$h_a = y - h_f$$

and,

$$\Delta h_a = - \Delta h_f$$

and Equation (8) becomes:

$$\Delta q_t = A_t (h_a - 0.5 \Delta h_f) \times \frac{g}{L} \times \Delta t \ldots\ldots\ldots\ldots\ldots (12)$$

For the beginning of the period, $t = 0$, y and h_f are known and h_a is found from Equation (4); y is the distance down from the forebay level to the center of gravity of the enlarged part of the surge tank in Fig. 2. Assuming the

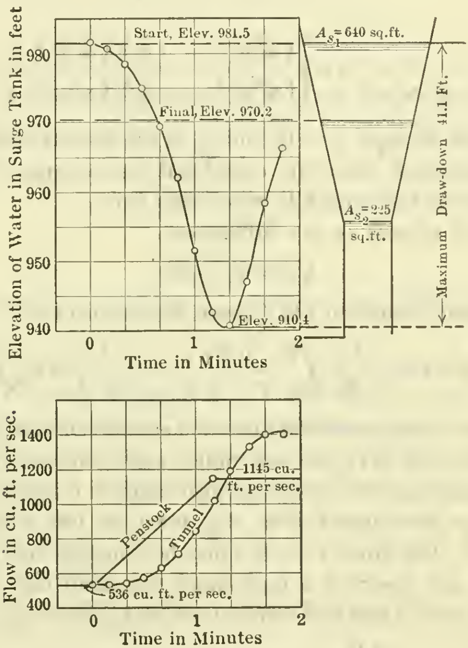

FIG. 14.

value for Δh_f, Equation (12) gives Δq_t, and the assumed value for Δh_f can then be checked. Δh_f can generally be closely approximated after the first or second step.

The volume required in the surge tank is then found as shown in Fig. 15 by plotting the tunnel flow and the penstock flow with respect to time. The area between these two curves is the deficiency which the surge tank must supply. It is to be noted that whenever Δq_t as determined from Equation (12) exceeds Δq_p, the rate of increase in the tunnel flow follows the rate of increase in the penstock flow and Equation (12) cannot be used until the instant Δq_t begins to fall below Δq_p.

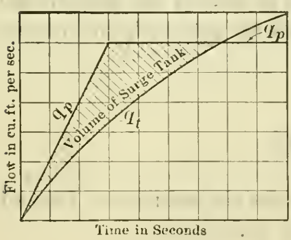

FIG. 15.

If Δt in Equation (12) approaches $d\,t$, and the flow in the tunnel is denoted by q instead of q_t, then from Equation (12):

$$d\,q = A_t \frac{g}{L} (y - h_f)\,d\,t \ldots\ldots\ldots\ldots (13)$$

This can be integrated, if

$$h_f = f\,q^2, \text{ so that } y > f\,q^2 \ldots\ldots\ldots\ldots (14)$$

Then, from Equation (12),

$$d\,t = \frac{L}{g\,A_t}\,\frac{d\,q}{y - f\,q^2} \ldots\ldots\ldots\ldots (15)$$

and,

$$T = \frac{L}{2\,g\,A_t\sqrt{y\,f}}\,l\,n\left[\frac{\left(\sqrt{y\,f} + f\,q_1\right)\left(\sqrt{y\,f} - f\,q_0\right)}{\left(\sqrt{y\,f} - f\,q_1\right)\left(\sqrt{y\,f} + f\,q_0\right)}\right] \text{sec.} \ldots (16)$$

where q_0 is the flow at time, $t = 0$, and q_1 is the flow at time, T. When q_1 is the flow in the penstock after the completed load change, T is the time required for the flow in the tunnel to reach this value.

The surge tank volume is the difference:

$$Q_s = Q_p - Q_t.$$

Q_p is known from Equation (16); from Equation (15):

$$Q_t = \int_0^T q\,d\,t = \frac{L}{g\,A_t}\int_{q_0}^{q_1} \frac{q\,d\,q}{y - f\,q^2} = \frac{L}{g\,f\,A_t}\,l\,n\sqrt{\frac{y - f\,q_0^2}{y - f\,q_1^2}} \ldots (17)$$

where q_1 is the flow in the penstock after the completed load change.

Equations (16) and (17) are not much more convenient than Equations (4) and (12), and, moreover, they are also subject to the condition that the rate of increase in the tunnel flow, $d\,q$, must be less than the increase in the penstock flow. The time, $t = 0$, must be counted from the moment this occurs. If this is not observed, a tank much too small may result.

In the case of the Kerckhoff surge tank test, shown in Fig. 9, ΔQ_p was 87 for $\Delta t = 10$ sec., or, $\frac{d\,Q_p}{d\,t} = 8.7$. If a surge tank, such as that shown in Fig. 2, had been used, $y = 984.2 - 934.2 = 50$ ft., approximately, and since $h_f = 2.7$ ft.,

$$\frac{d\,q}{d\,t} = 320\,\frac{32.2}{17\,000}\,(50 - 2.7) = 28.6$$

The flow in the tunnel, therefore, would increase as fast as the flow in the penstock, and the drawdown would be less than y until the penstock flow begins to increase faster than the tunnel flow can follow.

This point is determined by:

$$\frac{d\,q_p}{d\,t} = \frac{d\,q}{d\,t} = A_t\,\frac{g}{L}\,(y - h_f)$$

As y is known, h_f is determined, and this determines the value of q, beyond which a deficiency between penstock flow and tunnel flow occurs.

APPENDIX III

The general differential equations may be obtained from Equations (4), (10), and (8), by allowing Δt to approach $d t$. Then, from Equation (4):

$$d y = d h_a + d h_f \qquad (18)$$

and, therefore, from Equation (10):

$$d y = \frac{q_p - q_d}{A_s} d t \qquad (19)$$

and, from Equation (8):

$$d q_t = \frac{g}{L} A_t (y - h_f) d t \qquad (20)$$

These are the general differential equations; they cannot be integrated, except by assuming A_s, q_p, and h_f as constants, which they are not.

APPENDIX IV

Bibliography

Baum, F. G. Surges in Pipe Lines. *Engineering Record,* December 24th, 1910.

Durand, W. F. Investigations of Surge Phenomena by Means of Model Experiments. *Western Engineering,* Vol. 3, No. 6, p. 421.

——*Proceedings,* Am. Soc. Mech. Engrs., October, 1921.

Gibson, Norman R. Pressures in Penstocks Caused by the Gradual Closing of Turbine Gates. *Transactions,* Am. Soc. C. E., Vol. LXXXIII (1919-20), p. 707.

Johnson, R. D. The Surge Tank in Water Power Plants. *Transactions,* Am. Soc. Mech. Engrs., 1908.

——The Differential Surge Tank. *Transactions,* Am. Soc. C. E., Vol. LXXVIII (1915), p. 760.

Mead, Daniel W. Water Power Engineering.

Vensano, H. C. Pulsations in Pipe Lines. *Transactions,* Am. Soc. C. E., Vol. LXXXII (1918), p. 185.

Warren, Minton M. Penstocks and Surge Tank Problems. *Transactions,* Am. Soc. C. E., Vol. LXXIX (1915), p. 238.

——Air Tanks on Pipe Lines. *Transactions,* Am. Soc. C. E., Vol. LXXXII (1918), p. 250.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

TENTATIVE SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

SUBMITTED AS A PROGRESS REPORT OF THE SPECIAL COMMITTEE ON SPECIFICATIONS FOR BRIDGE DESIGN AND CONSTRUCTION

Discussion*

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FRANCIS P. WITMER,† M. AM. SOC. C. E. (by letter).‡—With regard to a column formula, the Committee seems still to have an open mind, or, more accurately, to have several minds more or less firmly made up along different lines. Three formulas are suggested as being in general use. None of these pretends to be an accurate theoretical formula, although that of Rankine comes closer to that status than either of the others.

The chief recommendation for either the straight line or the parabolic formula is that it agrees sufficiently well with tests and is readily applied. Because of their irrational form, neither is a correct formula to use for the calculation of the shearing stresses in a column.

A theoretically correct formula which agrees equally well with tests, has no limitations as to $\frac{L}{r}$, and may be used for calculating shear without too

* Continued from December, 1921, *Proceedings*.

† Cons. Engr., New York City.

‡ Received by the Secretary, January 6th, 1922.

greatly violating one's sense of mathematical fitness, would undoubtedly be most desirable, provided it also could be readily applied.

For long columns, the Euler formula which is based on an assumed initial deflection, and no initial eccentricity, seems still to be the best choice. For columns with ordinary length ratios, however, Euler's formula leads to unsafe values, and, therefore, the bending must be considered as due to an initial eccentricity, or to some cause equivalent thereto. For example, a modulus of elasticity varying from one side of the column to the other may be shown to be equivalent to an initial eccentricity.*

In Fig. 16, curves are shown for the following column formulas:

The Rankine formula:

$$S = \frac{16\,000}{1 + \dfrac{L^2}{13\,500\, r^2}} \qquad \text{(I)}$$

The parabolic formula:

$$S = 12\,500 - 0.25 \left(\frac{L}{r}\right)^2 \qquad \text{(II)}$$

The straight line formula:

$$S = 15\,000 - 50\, \frac{L}{r} \ \ (\text{max. } 12\,500) \qquad \text{(III)}$$

The straight line formula:

$$S = 16\,000 - 70\, \frac{L}{r} \ \ (\text{max. } 14\,000) \qquad \text{(IV)}$$

One-half the Euler formula for ultimate strength of round-ended columns:

$$S = \frac{1}{2} \left(\frac{296\,000\,000}{\left(\dfrac{L}{r}\right)^2} \right) \qquad \text{(V)}$$

One-half the eccentricity formula for ultimate strength of round-ended columns:

$$S = \frac{1}{2} \left(\frac{32\,000}{1 + \dfrac{e\,c}{r^2 \cos \dfrac{L}{2} \sqrt{\dfrac{P}{E\,I}}}} \right) \qquad \text{(VI)}\dagger$$

A formula of Rankine type:

$$S = \frac{16\,000}{1 + \dfrac{L^2}{Z\, r^2}} \qquad \text{(VII)}$$

in which Z has variable values, taken so as to produce a curve practically identical with Formula (VI), except that S has a maximum value of 13 000 (below $\dfrac{L}{r} = 30$).

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* "Columns", by E. H. Salmon, Lond., 1921.

† In Formula (VI), all columns are assumed to consist of two 15-in. channels, 33 lb., latticed, and the eccentricity, e, is assumed at 0.8 in. for all cases.

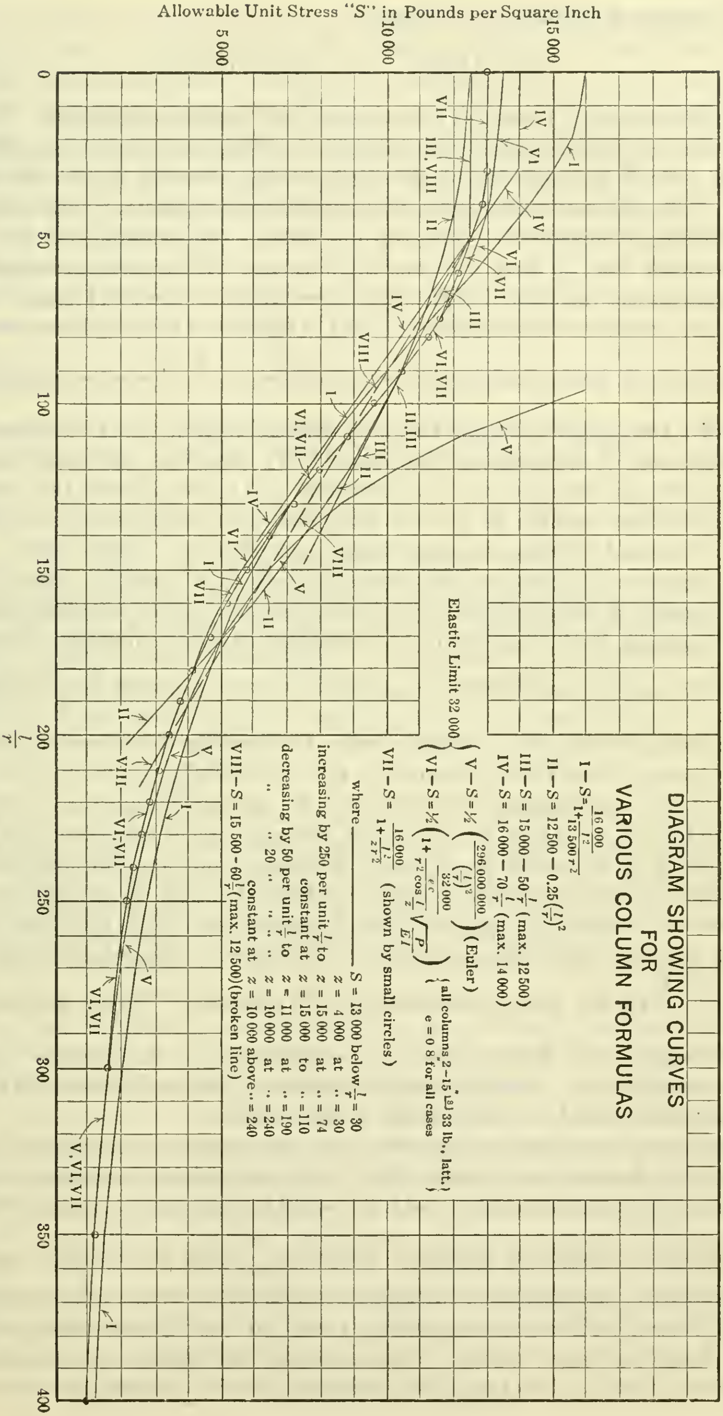
Allowable Unit Stress "S" in Pounds per Square Inch
15 000
10 000
5 000
0
50
100
150
200
250
300
350
400
$\frac{l}{r}$
DIAGRAM SHOWING CURVES
FOR
VARIOUS COLUMN FORMULAS
I — $S = \frac{16\,000}{1 + \frac{l^2}{13\,500\,r^2}}$
II — $S = 12\,500 - 0.25\left(\frac{l}{r}\right)^2$
III — $S = 15\,000 - 50\frac{l}{r}$ (max. 12 500)
IV — $S = 16\,000 - 70\frac{l}{r}$ (max. 14 000)
Elastic Limit 32 000
V — $S = \frac{1}{2}\left(\frac{296\,000\,000}{\left(\frac{l}{r}\right)^2}\right)$ (Euler)
VI — $S = \frac{1}{2}\left(\frac{32\,000}{1 + \frac{ec}{r^2 \cos\frac{l}{z}\sqrt{\frac{P}{EI}}}}\right)$
(all columns 2–15 ⊔ 33 lb., latt.)
e = 0 8 for all cases
VII — $S = \frac{16\,000}{1 + \frac{l^2}{z r^2}}$ (shown by small circles)
where S = 13 000 below $\frac{l}{r}$ = 30
z = 4 000 at " = 30
increasing by 250 per unit $\frac{l}{r}$ to z = 15 000 at " = 74
constant at z = 15 000 to " = 110
decreasing by 50 per unit $\frac{l}{r}$ to z = 11 000 at " = 190
" " 20 " " " " z = 10 000 at " = 240
constant at z = 10 000 above " = 240
VIII — $S = 15\,500 - 60\frac{l}{r}$ (max. 12 500) (broken line)
I
II
III
IV
V
VI
VII
VIII
III, VIII
VI, VII
II, III
V, VI, VII

Fig. 16.

A suggested straight line formula:

$$S = 15\,500 - 60\,\frac{L}{r}\ (\text{max. } 12\,500)\ldots\ldots\ldots\ldots\ldots\text{(VIII)}$$

For Formulas (V) and (VI) the elastic limit is assumed at 32 000. Formula (VI) not only corresponds, theoretically, to a constant initial eccentricity of 0.8 in. (which is about 5% of the depth of the column), but it can also be shown that this same percentage of eccentricity is consistent with a modulus of elasticity of nearly $E + 10\%$, on one side of the column, and $E - 10\%$, on the other side, so that it is also in harmony with a not unreasonable assumption as to variation in E. The curve of Formula (VI) agrees as well with test results as Formulas (I), (II), (III), or (IV), and has the additional merit of being continuous for all values of $\frac{L}{r}$, blending into Euler's curve for the higher values. The only valid objection to its adoption is the inconvenience of applying it. Formula (VII), therefore, has been devised to give practically the same curve as Formula (VI), but to have the advantage of the Rankine formula as to ease of application, except that the coefficient, Z, of r^2, instead of being constant, varies according to a simple law.

If objection is raised on theoretical grounds to a variable coefficient of r^2 in a formula of the Rankine type, it may be met by the argument that the Euler formula, itself, may readily be transformed into a Rankine formula, in which Z varies from 13 500 at about $\frac{L}{r} = 171$ to 9 250 at $\frac{L}{r} =$ infinity. Why, then, should not a variable value be considered reasonable for lower length ratios, where Euler's formula is not applicable?

A little consideration will show that the column shear due to assuming the bending to be caused by an initial eccentricity, is less than that due to assuming it to be caused by an initial deflection, and, therefore, to be on the safe side, the latter assumption should probably be made in calculating shearing stresses, although at some sacrifice of consistency. With a column formula of the Rankine type, this assumption will lead to a shear having the value, $V = \frac{\pi\, P\, L}{Z\, c}$ (if the curve is assumed to be a sinusoid), P being the total load, L the length, c the distance from the neutral axis to the extreme fiber, and Z the coefficient of r^2 in the Rankine formula. Hence, Formula (VII) may be consistently used for calculating column shears.

Although the Committee probably will not consider it advisable to adopt so radical a formula as Formula (VII), with its variable coefficient, it cannot be denied that some formula would be desirable, that had a rational form and that would be applicable to higher values of $\frac{L}{r}$ than the limiting ones prescribed in the specifications. Although adherence to these values admittedly would control ordinary bridge design along safe and proper lines, yet there is no doubt that any formula recommended by the Society will be applied on occasion to higher values than those prescribed, as, for example, in investigating

the strength of existing structures, or in the design of special structures, such as transmission towers; and the formula recommended should not lead to results either dangerous or unduly on the safe side. Formula (II) would produce the latter result, and Formula (III), the former, if pushed to extremes. Formula (I) would be fairly conservative, but its curve lies considerably above that of Euler for higher length ratios, and this makes its use in such cases questionable. Undoubtedly, Formula (VI), or its simpler equivalent, Formula (VII), would be preferable, if it were not considered too difficult of application.

If a straight line formula was adopted finally, it would seem that it should lie somewhere between Formulas (III) and (IV), as, for example, a line passing through $S = 12\ 500$ at $\frac{L}{r} = 50$, and drawn tangent to Euler's curve, V. Formula (VIII) is suggested as approximating these conditions. Its results would not differ materially from those of Formulas (I), (II), or (III), for ordinary length ratios, and it could safely be used up to $\frac{L}{r} = 200$, since it does not depart materially from Euler up to that point.

In conclusion, the writer wishes to emphasize once more the suggestion that the formula ultimately adopted by the Committee should be one which can be properly used by engineers, with a minimum of reservations as to its applicability, because it may be safely predicted that it will be extensively used on its own merits, entirely apart from the general body of the specifications, in view of its authoritative source, and, therefore, it should not be in any degree misleading.

C. A. P. Turner,* M. Am. Soc. C. E. (by letter).†—The importance of the proper design of compression members was forcibly illustrated at Quebec. In view of the approach to the make-up there used in many bridge structures, the detail make-up of compression members rather than minor differences in theoretical formulas, should be given first consideration.

Burton R. Leffler, M. Am. Soc. C. E., a member of the Committee, states that it was impossible for the members to agree on one formula.‡ His preference is for the parabolic formula, because the curve fits a series of tests to the point of tangency to Euler's curve. Let the basis of the derivation of the Rankine formula and the Euler formula be considered.

Euler treated of a solid prism. Rankine treats of pillars and struts from the viewpoint of their resistance to crushing by bending, presenting the Tredgold-Gordon formula buttressed by Hodgkinson's experiments on rectangular sections of solid wrought iron with cast-iron solid sections and hollow cylinders.

How does Euler's formula apply to the cellular or general make-up of the bridge member? Under compression, the material tends to deform in the simplest manner to relieve itself of the applied crushing or compressive force. If the section is solid, such as a solid cylinder, no relief is afforded by shorten-

* Cons. Engr., Minneapolis, Minn.

† Received by the Secretary, January 9th, 1922.

‡ *Proceedings*, Am. Soc. C. E., December, 1921, p. 728.

ing through twisting. Hence, failure of the solid prism under crushing forces takes place by bulging if it is short, and by combined flexure and compression if it is long. In the hollow cylinder the same rule holds true, but in the rectangular section, shortening of the length can occur by twisting as well as by bending. Torsional distortion caused by compression must be considered, in addition to the tendency to bend and thereby shorten the distance between the ends or points of application of the compressive force in built rectangular or laced channel sections.

Torsional rigidity constitutes one criterion of the ultimate strength of the structural column. Without theoretical training, the workmen in the shop at Phœnixville, Pa., as the investigation of the Quebec failure disclosed, recognized this relation so clearly that they questioned the strength of the huge compression members built for the Quebec Bridge. How well founded was their suspicion of lack of strength, subsequent events disclosed.

The elements of make-up which affect torsional rigidity, are the stiffness of the lacing-bars for preventing buckling or twisting out of line of the flanges of the riveted channels. The relative breadth and stiffness of the flanges in keeping the web in line prevents its buckling or, if laminated, the separation and individual buckling of its parts.

Tests of small size compression members, consisting of solid rolled channels, may bear little relation to large riveted compression members of the heavy bridge through lack of concentration of 40% of the metal in the flanges and lack of relative breadth of the flanges of approximately 25% of the total depth of the web. When these proportions are adhered to and, in addition, the stiffness in bending of the lacing-bars is made proportional to the greater area of cross-section of the riveted channels connected thereby, one may consider that the same formula will apply to each section approximately, although just what allowance should be made for the plates merely riveted together in contradistinction to a solid rolled section, is by no means a simple determination. To secure comparable stiffness in the largest measure, angle-iron rather than flat bar-lacing should be used, and diaphragms at reasonable intervals may advantageously be utilized. An increase of strength of compression members, over those ordinarily designed, of from 25 to 30% may be thus secured, a matter of greater magnitude than the moderate differences between the straight line and the parabolic formulas proposed by the Committee.

Although the writer has succeeded in the stress line analysis of flat plates buckled under load requiring only the additional data of the length of the load line, in order to determine immediately the contours and relative deflections, he has failed to progress further in consideration of the columns than to demonstrate that flexure and crushing only need be considered in the prismatic or solid section, whereas torsion, bending, and crushing should be considered in any rational formula for rectangular sections or for those differing materially from the symmetrical cylinder. This is one of the reasons which convinced the writer that the reinforced column with a proper percentage of hooping and vertical steel is more dependable as a compression member than the steel bridge member as commonly built to-day.

Several years ago, the writer examined the scrap pile, representing the test to destruction of specimens of various sections in compression at the Bureau of Standards, and the twisting of the Z-bar sections and some of the channel and plate sections was so marked that he doubts if any one taking the time to examine them carefully would fail to be impressed with the importance of torsional resistance in determining the strength of built-up columns in bridge design.

James E. Howard,* Esq. (by letter).†—Concerning specifications for tensile tests in general, it is not regarded a matter of special importance to invite attention to the total elongation specified, nor to the permissible speed of testing. Lest, however, these clauses be taken for more than they are worth, a few remarks on them may be made.

Article 902 calls for an elongation of 25% in a 60 000-lb. steel, on an 8-in. length. It will be borne in mind that general elongation and that incident to contraction of area are commonly considered together, giving an exaggerated value in the reported elongation. If a true statement of the elongation of the material is necessary, local contraction should not be allowed to distort the result. A 2-in. specimen has little value in showing the elongation of the steel, unless its length is observed at the time of reaching the maximum tension and before local contraction sets in. As tests are commonly conducted, there is little opportunity for doing this.

In regard to the rate of speed in testing, taking it at 2 in. per min., according to Article 907, the rate becomes 0.033 in. per sec. An 8-in. specimen, at an elastic limit of 30 000 lb., displays a strain of 0.008 in. Disregarding the strains of the testing machine, at the above rate the elastic limit will be reached in ¼ sec. Putting this limit on the maximum speed of testing is, of course, unnecessary.

Referring to the subject of column formulas, it appears to the writer fundamentally desirable to restrict the length of columns when feasible to do so. The failure of a column, if it occurs, is likely to be the result of an emergency, such as being called on to act as a collision strut.

The manner of failure in the last stages of long and short columns differs. A period is reached in the failure of a long column when sudden lateral deflection, or springing occurs, attended with great loss in resistance. If, perhaps, a long column was forced out of line a certain amount, collapse of the structure would certainly follow. A sudden drop in sustaining power is not characteristic of a short column.

Concerning column formulas, the writer has been forced to take a position at variance with prevailing views, raising the question whether, in practice, they are what they purport to be.

An early series of tests on Phœnix columns was made by the writer, the results of which have been reported to the Society by Messrs. Clarke, Reeves, and Company.‡ Certain queries arose during the making of these tests, which

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† Received by the Secretary, January 13th, 1922.

‡ "Experiments upon Phoenix Columns", *Transactions*, Am. Soc. C. E., Vol. XI (1882), p. 1.

led to another series soon thereafter on plain square bars. The latter measured 3 in. on a side, were tested chiefly with pin-ends, and were of different ratios of slenderness.

At the time of these tests, few modified column formulas had been presented, those of Euler, Rankine, or Gordon being in use. A feature was brought out in the tests of the square bars, not peculiar to these small members, but common to structural shapes, which seemed to militate against any formula except a purely empirical one, namely, the presence of a state of internal strain which arose from two causes, the cooling strains of fabrication, and those set up by cold straightening. Although the investigation of these internal strains was not undertaken until some years later, when numerical values could be assigned them, nevertheless the importance they played was then quite evident.

It appeared subsequently that internal strains from these two causes differed somewhat. Strains from cold straightening were more likely to influence the results of compression tests than cooling strains, considering each separately, and as applied to long columns. The reason for this was that internal cooling strains might and probably would leave a substantial margin between the value of the elastic limit of the metal and their own magnitude. This margin would represent the external stress that the member could endure without taking a permanent set, that a state of residual perfect elasticity of some degree, would remain in the member.

Cold straightening is an overstraining of the metal, in which there is impairment of the elastic limits of tension and compression, in addition to which internal strains are set up by the resilient action of the metal when the straightening force is removed. These internal strains are left in a state of equilibrium, but delicately poised, in which their relations to each other are easily disturbed.

Having these features in mind, it appeared that the elastic limit of a column would vary in different parts of its cross-section, and, as early permanent sets would develop locally, that the strength of a long column in particular would be affected by the state of internal strain of its component parts. Here was a factor, it seemed, that might have an influence on the strength of the column of such degree that the application and use of a formula would be nullified.

Internal strains have no influence on the modulus of elasticity of the metal, except that overstraining is known to lower temporarily its value, but from which there is early recovery. The presence of internal strains leads to the display of early sets, perhaps premature local buckling, and local yielding has its effect on the ultimate strength of compression members. Failure in this manner is not taken into account in a column formula.

These remarks explain the writer's point of view. If it should be found that internal strains ordinarily reach fairly high values, it would tend to justify holding such a position.

Internal strains in rolled, hammered, and cast members, have been the subject of investigation by the writer for a long term of years. It was not until recently, however, that steps were taken to acquire information on the cooling strains in certain structural shapes.

Stresses corresponding to the measured internal strains were as follows: At the edge of one leg of a 4 by 6-in. angle, the compression was 6 600 lb. per sq. in., and at one flange of an 8-in. I-beam, 12 200 lb.; at another flange of the same beam, the tension is 3 300 lb., making a range of 15 500 lb. per sq. in. A 12-in. plate showed 8 700 lb. compression at one edge, and 10 500 lb. compression at the other edge. A 12-in. channel showed a maximum compression of 13 200 lb. A duplicate channel, in another part of its section, showed a tension of 11 100 lb. The range, therefore, was 24 300 lb. per sq. in.

Internal strains equivalent to working stresses, according to current practice, can hardly be regarded with indifference in their relation to a column formula, and, not being taken into account, may assist in explaining the recurrence of the discussion of the subject.

Crosby Miller,* Assoc. M. Am. Soc. C. E. (by letter).†—The specification for steel railway bridges shows a great deal of work on the part of the Committee, the result of which is a credit to the Society. However, in view of the fact that the specifications are apparently based on the latest specifications of the American Railway Engineering Association, it would be well to see whether that Association will incorporate in its own specifications, the improvements developed, before the adoption of any specification is considered by the Society.

Further, the Society should consider the development of a specification using a unit tensile figure of about 23 000 lb. per sq. in., and a live load that would represent the greatest live load which, in the opinion of the designer, would ever pass over the structure, this live load to be expressed in Cooper's loading. A specification of this type will result in a saving in material, due to the use of a higher unit stress for dead load, and, where no future load greater than E-60 is anticipated, would allow the use of a lighter structure.

C. D. Purdon,‡ M. Am. Soc. C. E. (by letter).§—Since the specification for steel railway bridges of the American Railway Engineering Association has been generally adopted, it is questionable whether one which is practically similar, should be issued by the Society.

The specifications of the American Railway Engineering Association are for fixed spans less than 300 ft. in length, whereas those presented by the Committee do not limit the length. Mr. Seaman‖ states that the formula of the American Railway Engineering Association is "particularly objectionable in long spans", overlooking the length limit of its specification.

Article 7.—The Committee specifies that drawings shall be made on the dull side of tracing cloth. The American Railway Engineering Association has made the same stipulation for the reason that the tracings become the property of the purchaser (or company). If the tracings do not become the property of the purchaser, the contractor should be allowed to make them to suit himself.

Article 12.—The width, center to center, of trusses, as stipulated by the Committee, should not be less than one-twentieth of the span; the American

* Bridge Engr., Chesapeake & Ohio Ry., Richmond, Va.

† Received by the Secretary, January 13th, 1922.

‡ Cons. Engr., St. Louis Southwestern Ry., St. Louis, Mo.

§ Received by the Secretary, January 13th, 1922.

‖ *Proceedings*, Am. Soc. C. E., December, 1921, p. 717.

Railway Engineering Association has stipulated one-fifteenth of the span. As Fig. 1 shows a clearance of 16 ft., this would not apply to through spans of less than about 400 ft.—while deck girders (Article 601) should not be less than about 4 ft. (according to Article 12) "but not less than 7 ft. 6 in. between centers"—apparently, the one-twentieth might be omitted. The American Railway Engineering Association limits the length of the panel to 1½ times the width.

Article 15.—Where there is much snow, the guard-rail bolt should be countersunk flush with the top of the guard-rail; a snow plow may strike it.

Article 16.—Why not take the actual load per foot? The alternate load of 75 000 lb. on each of the axles on a 10-ft. span equals 15 000 lb. per ft. as a maximum.

Article 17.—The American Railway Engineering Association allows the distance between centers of gravity on plate girders, provided it does not exceed the distance back to back of flange angles.

Article 104.—The writer thinks it would be better to make the diagram E-10 and make the lower limit E-45. For many branch lines, engines of about E-25 loading are ample for the loads they have to haul, and E-60 means hauling so much more dead load. The limit of E-45 would take care of such cars as the 50-ft. gondolas of 70 tons capacity, of the Pennsylvania Company.

Article 201.—The writer suggests that the 25% should be applied to field rivets also. The average ultimate extreme fiber stress in bending is: Douglas fir, 6 100 lb. per sq. in.; long-leaf pine, 6 500 lb.; and white oak, 5 700 lb.; but this specification gives the same value to each; besides, white oak warps so much in seasoning as to make it unsuitable for bridge ties, at least, in the South.

Article 336.—As the coefficient of expansion for steel is 0.0000065 per degree Fahrenheit, it would seem that the coefficient of the American Railway Engineering Association of 1 in. per 100 ft. is ample.

Article 339.—The writer would add that "segmental rollers may be used".

Article 403.—The writer would add "but far enough apart to allow of cleaning and painting".

Article 701.—The writer does not understand the phrases "or with a web". and, "lacing on the open sides". If the truss is made of two side segments and one cover-plate, there is only one open side. Does it mean that a center web may be added?

Article 703.—The writer would add "and live load without impact".

Article 1105.—Long girders should be loaded according to M. C. B. rules. In connection with impact, Mr. Seaman mentions that some English experiments gave 125% on a length of 7 ft. 6 in. The alternate loading of 75 000 lb. on each of two axles, 7 ft. 6 in apart, gives over the regular loading, 25% on a 5-ft. length, reducing to 11% on a 10-ft. length; this, with the impact formula of the American Railway Engineering Association, would give an impact of 125% on 5 ft.

This alternate loading does not affect a length of more than 11 ft. Mr. Seaman seems to have overlooked the fact that the American Railway Engineering Association specification is limited to spans of less than 300 ft.

Prof. Turneaure* states clearly the reasons of the American Railway Engineering Association for adopting the Cooper loading; but some of his diagrams give an equal weight on driving axles.

G. B. WOODRUFF,† ASSOC. M. AM. SOC. C. E. (by letter).‡—The writer hopes that the final result of the work of this Committee will be the forming of a joint committee and the production of a specification for steel railway bridges that may find more general adoption than any heretofore produced.

This tentative specification, as was to be expected, follows very closely the specifications adopted in 1920 by the American Railway Engineering Association, a large percentage of the subject-matter being copied. Where changes have been made, the writer believes that, in most cases, they are an improvement, and that, in general, the arrangement and the wording are better.

The following suggestions as to the detail specifications are offered:

Article 10.—Rolled beams can be used to advantage up to spans of 35 ft.

Article 11.—In order that the main-track alignment may be kept straight, it is often desirable to build four-track bridges with four trusses.

Article 101.—Add "ballast 120 lb. per cu. ft." With heavy rails (135 lb.) and guard-rails, rails and fastenings will weigh more nearly 200 lb. per lin. ft. of track.

Article 105.—The writer prefers the stating of these percentages as given in the specifications of the American Railway Engineering Association.

Article 108.—The writer believes that economy of design requires the use of a heavy live load (say, Cooper's E-90) and of increased unit stresses. By this article, a 50% increase in live load would increase the unit stresses in stringers, hangers, and some web truss members about 50% above the specified values, while the chord members of heavy bridges would be overstressed, say, only 25 per cent.

Article 109.—Change "10% of the specified live load" to "700 lb. per lin. ft." The latter is more simple to calculate, and will give, as nearly as is required, the same result.

Article 112.—This article is incomplete in that it fails to specify the velocity for the different degrees of curvature. Paragraph 36 of the American Railway Engineering Association specifications is preferable.

Article 201.—The shearing unit stress in plate-girder and I-beam webs, if correctly stated, is new, the usual specified values being 10 000 lb. on gross section or, in some specifications, 12 000 lb. on net section. The writer prefers the use of the net section, because it leads to details that do not cut up the web as much as when no restriction is placed.

Article 206.—The writer assumes that it is the intent of this article that verticals and the floor-beams be treated as a continuous frame hinged at the unloaded chord. The lacing of such members should be designed to carry the shear resulting from the bending moment, in addition to $2\frac{1}{2}\%$ of the direct stress. It might be advisable for some member of the Committee to explain the proposed method of calculation.

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 720.

† Asst. to Bridge Engr., Lehigh Valley R. R., Bethlehem, Pa.

‡ Received by the Secretary, January 17th, 1922.

Article 209.—The formula contained in this article does not seem to harmonize with the reduction in column unit stresses.

Article 308.—The writer would suggest amending this article to read "connections of members carrying live load stresses".

Article 318.—The length of the stay-plate for tension members should be specified.

Article 336.—The writer believes that provision for an expansion of 1 in. for every 100 ft. in length is sufficient. He is familiar with a number of bridges where the expansion bearings have been marked to determine the expansion, and believes the figure given is more than sufficient.

Article 602.—This paragraph is somewhat indefinite. The writer assumes that it is intended that one-eighth of the gross section of the web may be considered as the net flange section.

Article 603.—It may be called "practicable" to use 8 by 8 by 1-in. angles, with no covers, for a girder flange. The old specification that "preferably the angles compose 50% of the flange section and in no case shall the flange cover-plates compose more than 60%", is more definite.

Article 605.—It is not required that a cover-plate be entirely developed at its theoretical end. This specification tends to space rivets so close together at the end of the plate as to reduce the net section.

Article 608.—Flange splices are necessary in very long girders, and the writer believes that this specification should be extended as in those of the American Railway Engineering Association.

Article 703.—The writer believes more camber should be provided. The dead load deflection in short trusses is nearly negligible.

Article 801.—Single bents usually occur at the curb line at street crossings. The longitudinal force is resisted by the friction of the end spans, but the bents (and anchorages) must take the temperature stresses which are often greater than those from longitudinal force.

Article 902.—There have been recently published rules for the rating of old structures, which allow a unit stress of 26 000 lb., with secondary stresses not considered. It would seem that the margin between this and a 30 000-lb. yield point is very small. Some railroads are now specifying a 33 000-lb. yield point and practically the same elongation and bending tests.

Article 1003.—The writer does not believe that full punched work, for main sections, has any place in a present-day specification for railroad bridges, especially if that metal is to be stressed to 26 000 lb. per sq. in., and considering that, in the bridge shop, workmanship is subordinated to tonnage.

The writer hopes that the Committee will extend and continue its work. Specifications for highway bridges are especially needed at the present time, and it is to be hoped that this Committee and that of the American Railway Engineering Association will co-operate to form one that will receive general adoption.

It is also to be hoped that other committees of the Society can be formed to recommend standard practice in other branches of the Profession. The writer believes that nothing could arouse interest and increase the usefulness of the Society to the Profession so much as by following the example of some of the other engineering societies in extensive committee work.

J. E. Crawford,* M. Am. Soc. C. E. (by letter).†—A careful review of this specification shows that there is no substantial difference between it and the specification of the American Railway Engineering Association of 1920.

The specification of the American Railway Engineering Association is the result of years of study and work on the part of railroad bridge engineers, representing the major portion of the tonnage of railroad bridges constructed in the United States, and applies definitely to railroad bridges with spans of 300 ft.

The only benefit which might be derived from having a specification prepared independently by the Society would be that it would cover the construction of railroad bridges of spans in excess of 300 ft., and having to do with problems relating more especially to the design and construction of long-span bridges, in connection with which a number of the members of the Society have had valuable experience.

It is the writer's judgment that the specification as drafted has not sufficient material of value not already covered by the specification of the American Railway Engineering Association, to warrant its publication.

C. E. Conover,‡ M. Am. Soc. C. E. (by letter).§—The writer has considered with some care the bridge specifications proposed by the Committee. Based on his examination, he wishes to congratulate the Committee on framing a specification of such an excellent character, and it is his opinion the Engineering Profession should appreciate the splendid work that the Committee must have done to secure such excellent results. The attention of the Committee is called to certain matters that have suggested themselves to the writer.

In Article 107, impact formula for bridge design for electric traction: From all information that has come to the writer's attention, cars equipped with direct drive produce but little impact, probably not more than 10% for ordinary speeds. As a matter of fact, probably most of that comes from imperfect track or wheel conditions. It is believed that the impact for such bridges could be reduced so as to be not more than 25 per cent.

In Article 605, length of top cover-plates of girders: The writer would suggest that for girders used as track floor stringers, all top flange-plates should extend the full length and the rivets should be countersunk in the top of the top flange, in order to avoid dapping of ties and consequent increased expense of laying and maintaining track. It is desirable, where relatively short spans are used, that such longitudinal girders should not have any cover-plates, even should it be otherwise necessary to increase slightly the depths of the girders.

In Article 804, depth and spacing of girders: The writer would suggest for bridges for electric railway operation, with cars operated by direct-drive motors, that the girders might as well be 5 ft., center to center, reducing the strain on the ties. As previously noted, it is his judgment, based on information that has come to his attention, that the impact in the case of such cars

* Chf. Engr., Norfolk & Western Ry., Roanoke, Va.

† Received by the Secretary, January 18th, 1922.

‡ Designing Engr., Transit Comm., New York City.

§ Received by the Secretary, January 24th, 1922.

is very small. There seems to be little necessity for attempting to eliminate the direct effect of this impact by not having wheels directly over the girders.

F. P. Turner,* Assoc. M. Am. Soc. C. E. (by letter).†—The writer has carefully read the proposed specifications and has compared each paragraph with the corresponding paragraph of the Specifications for Steel Bridges of the American Railway Engineering Association, as adopted in 1920. Although there are some slight differences in the intent, as indicated in a few paragraphs, the essentials are the same in both specifications, namely, clearances, loading, impact allowances, unit stresses (with the addition of alternate compression values), details of design, shop work, and specifications for material.

The discussions on loading, impact and column formulas, as presented by Mr. Seaman, Professor Turneaure, and others,‡ have been read with interest, and the writer feels that, although a few tests are recorded, showing that impact values greater than 100% have been obtained on spans less than 30 ft. in length, the result of extensive studies and tests made by the Committee of the American Railway Engineering Association, and presented in its 1920 Specification for Railroad Bridges, on spans as great as 300 ft. in length, having impact values not to exceed 100%, will produce safe and satisfactory structures, conforming practically to the best present-day practice on American railroads.

Edward Godfrey,§ M. Am. Soc. C. E. (by letter).‖—The Committee is to be commended for the excellence of these specifications. They are a good index of the state of the art of building railroad bridges and show the effort on the part of the Committee to define good, substantial structures.

The more that individual judgment can be eliminated and good rules adopted and enforced, the better will be the structures produced. It is to be hoped that advocates of a detailed set of specifications will prevail, and that those who advocate the adoption of a more general specification will fail.

The arrangement of these specifications is excellent, but there are reasons for the placing of many of the Articles under Section 10, "Workmanship", in Section 3, "Details of Design". Under the heading, "Workmanship", one looks for that which concerns the shops, where the steelwork is fabricated. Many paragraphs in Section 10 concern the draftsman, since they affect the making of the shop drawings, rivet lists, and sketches which the draftsman must furnish for use in the shop. It should be possible for a bridge office to copy the parts of a specification that pertain to the shop work.

Other Articles wrongly included in Section 10, are as follows: Article 1004, which deals with the reaming and drilling of rivet holes; Article 1014, which deals with orders of field rivets and has no bearing on workmanship; Article 1016, which states how web-plates may be ordered and detailed; Article 1018, which gives thread standards; and Article 1020, which states how bearing plates are to be detailed. All these pertain to the making of detail drawings,

* Bridge Engr., Norfolk & West. Ry., Roanoke, Va.

† Received by the Secretary, January 24th, 1922.

‡ *Proceedings*, Am. Soc. C. E., December, 1921, p. 710.

§ Structural Engr., Pittsburgh, Pa.

‖ Received by the Secretary, January 26th, 1922.

and are not for the interpretation of the shopman where workmanship is of vital importance. Other Articles of which the same may be said, are as follows, 1022, 1027, 1029, and 1032.

Inspection bureaus are also interested in grouping the paragraphs pertaining to workmanship, so that they can be copied for the use of inspectors. Anything that aids the inspector makes for a better class of work in the shops. Draftsmen are interested in having matters that pertain to the making of shop drawings collected under one heading.

It is gratifying to note that the Committee retained the Cooper system of engine loading, not because it represents exactly or closely engine loads in use, but because engineers have become familiar with it. To translate any given system of loads into an equivalent in the Cooper scale is not difficult.

The method for estimating the weight of structural parts, Article 1103, seems to be excellent in every respect. Some structural concerns will estimate steelwork without making any allowance for cuts, pin-holes, or rivet holes. The weight of plates that are ordered in multiple lengths and sheared on a bevel, will be computed as though each piece was rectangular. These same forms add the full allowance of overweight for wide plates, and also add a percentage for shop paint. By this means they charge for a large weight that does not go into the structure. In the allowance for shop paint, there is some defense, inasmuch as the computed weight is frequently used in place of scale weights of the pieces as shipped, and it would not be out of place to add a small amount, say, one-half of 1% of the estimated weight of the steel, for the shop paint.

In Article 107, the impact for bridges to carry electric traction exclusively, is required to be one-half as great as for railroad bridges. In the writer's judgment, an impact allowance of 25% for all members of a traction bridge is sufficient. Impact is due almost, if not, entirely to roughness of the track or unbalanced wheels. The effect of impact on any member has little or no relation to the length of span or loaded portion; it depends on the imminence of the member to the track. In very short spans, the member or girder is naturally closer to the track, and tests show higher impact. There is nothing in test results of impact observations to justify a formula that varies the impact with the span length. The only rational method of taking care of the dynamic effect of rolling loads is one on the order of Cooper's specifications, in which the effect of live load on a member is varied in accordance with the directness of its action on that member. In the matter of traction bridges, it seems that the standard practice could have been retained, of using an impact of 25% of the live load on all members.

If one sits on the bottom chord of a bridge while a 5-ton automobile passes at a great speed over the bridge, and from the same location compares the results with what happens when a horse trots across, pulling a light wagon, one will be convinced that the suddenness of application of the load has little to do with the dynamic effect, whereas vertical vibration, due to the roughness of the floor or the track, or any other cause, has a large influence.

It is unfortunate that the Committee could not agree on a column formula and that such divergence of practice should be recommended in the matter of the design of compression members as is shown in Article 201. No column

formula can be even approximately correct that fails to take into account imperfections in columns, this is particularly true for structurally permissible columns. Years ago, engineers observed that, in the zone of structurally permissible columns, test results were grouped about a practically straight line and then curved up in the zone of slender columns. On the strength of this, the straight line formula for columns was urged and, later, generally adopted.

This straight line formula is suitable because it not only is simple of application, but it also virtually recognizes imperfection in columns, since it comes nearer to an agreement with the strength of commercial compression members than any other formula in use.

Among engineers who favor theory, there seems to be a movement to return to the curved line formulas. The chief argument for the curved line formula is the inapplicability of the straight line formula to slender columns—columns outside the range of structural specifications. If the straight line formula was shown to give false results in the limits where it is used, this would be an argument against it; but because it fails to give proper results in a field where the use of compression members is forbidden, is no reason for its abandonment.

A formula that would give a "whip shaped" curve of column unit stresses, that part in the region of permissible structural columns being straight and that in the "slender" zone curving up, would agree best with test results. A curve of this shape would naturally have a complex equation, and its use would impose an unnecessary burden on the computer.

That test results do group around a "whip shaped" curve has been shown in results published in an article* which is a plea for the revival of the Gordon-Rankine formula.

There is no reason why the straight line formula should not be used for columns up to the maximum ratio of slenderness permitted in structures, slender compression members such as posts for transmission towers and struts for airplanes, being designed by a formula appropriate to that used in the design of long struts. The Euler formula is the proper formula for this purpose, but it is useless for designing structurally permissible columns.

In the writer's book, "Steel Designing", a column formula is derived, the locus of which is practically a straight line within the limits of structurally permissible columns and which curves up in the zone of slender columns. It is practically coincident with the straight line formula in common use, where that formula has application. This "whip shaped" curve has a formula that is too cumbersome for practical use. It is, however, a rational demonstration of the correctness of the straight line formula for use in designing, for its derivation is completely rational, and there is only one assumption made, namely, that the column is imperfect to the extent of being bowed with an offset $\frac{1}{300}$ of its length. On this hypothesis, a formula is derived that gives the unit stress on the column, which, combined with the unit fiber stress due to bending and consequent deflection, gives a total extreme fiber stress of 16 000 lb. per sq. in. A bow exceeding $\frac{1}{300}$ of the length of a column would be readily detected, whereas one somewhat less, would be difficult to detect.

* *Engineering News-Record,* March 10th, 1921, p. 431, Figs. 1, 2, and 5.

It would seem, therefore, that this formula would give, not only safe results, but also economical proportions for compression members. Only the equivalent of the straight line part of the cumbersome formula is recommended for use, namely, the commonly used straight line formula for shorter columns. No better justification of that formula is needed than the well known agreement with tests and this theoretical substantiation.

In the list of allowable unit stresses is given the straight line formula, with a base of 15 000 lb. per sq. in. Tests demonstrate that steel is not as good in compression as in tension. It is not clear why the user of the Gordon-Rankine formula should be allowed a maximum unit stress of 14 300 lb. per sq. in., whereas the user of the straight line formula is allowed a maximum of 12 500 lb. per sq. in. There is no connection between the type of formula used and the maximum unit stress allowed. It seems well to adopt an upper limit of 12 500 or 13 000 lb. per sq. in.

With regard to the allowance for centrifugal force in bridges, Article 112, it would be well to specify the speed to be used in the computation. It is recommended that the provision of some specifications be adopted in which $V = 60 - 3\,D$, in the formula, in which D equals the degree of curvature.

In Article 113, it is stipulated that the tractive force be applied 6 ft. above the top of the rail. Every requirement of good design is met if it is applied at the track level.

In Article 201, the unit pressure allowed on concrete masonry is 600 lb. per sq. in., which gives an undue advantage to concrete over limestone masonry which is allowed 400 lb. per sq. in. Bridge seats are seldom grouted or embedded in a manner that would give a true bearing, and for this reason unit pressures should be kept low.

Article 206 in which bending stress due to floor-beam deflection is mentioned, and Article 208, on "Secondary Stresses", provide refinements that are unnecessary. Secondary stresses are seldom considered in the design of structures. For example, take the case of a girder rigidly connected to the side of a column. The column would have to be designed for a bending moment due to deflection of the girder, and this is seldom done. Suppose, that, theoretically, this rigid connection gives a bending moment that is excessive and the designer concludes that he will place the girder on a bracket on the side of the column. In this case there is a bending moment that should be considered, because it cannot be taken by the girder which is amply able to take it. This construction is inferior to the first, because it lacks rigidity. If, to improve the detail and to supply the rigidity, a top and bottom flange connection of the girder to the column is introduced, the theoretical equivalent of the first plan is secured without its practical benefit.

To avoid all bending moments, suppose the girder is placed on the top of the column. To effect this, it will be necessary to use a pin bearing-shoe or its equivalent, because if the girder rests on the squared end of the column, the deflection of the girder will produce theoretical bending moments. A pin bearing-shoe, in general, would be impracticable.

Secondary stresses and bending moments due to deflection of floor-beams may be safely ignored in ordinary structures; in fact, it is doubtful whether they need ever be considered.

The specifications should contain some definite rules for computing certain unavoidable stresses and moments, which although they are frequently ignored, should be considered. Examples of such requirements are as follows:

1.—The bending moment on a transversely loaded chord will be calculated as if each panel of the chord was a beam, simply supported at the ends. For the splice near panel points one-half of this moment will be used.

2.—Girders and trusses for skew spans, in general, will be calculated as if the spans were square. (In some cases, a little more steel will be required, but it will produce girders that can be converted into square spans if need be, and it simplifies calculations.)

3.—The accumulated wind load of the top lateral system in through bridges will be assumed to be divided equally between the four end-posts. The bending moment in an end-post will be taken as the product of the shear carried by the distance from the shoe to the bottom strut of the portal (or to the foot of the brace, if it is substantial and not ornamental); this is to be reduced by the product of the dead load stress in the end-post by half the distance between the webs of the end-post unless this reduction diminishes the original moment by more than one-half, in which case one-half the original moment is to be used as the bending moment due to wind.

It would also be well if the specifications contained a definite pronouncement on the subject of tension on rivet heads. Inhibition of tension on rivet heads defeats its own purpose, whether that purpose is to secure good design or to prevent such tension. Tension on rivet heads supplies the rigidity and stability to all riveted structures. Without it, structures would rattle and fall apart; it is this tension that supplies the friction that plays a major part in holding riveted pieces together.

Hardly a design can be made that does not involve some direct tensile stress on rivet heads. Rivets are capable of taking a large amount of tension on the heads and, with proper design, of doing so with safety.

On this subject the following substitution is recommended:

"Tension on rivet heads will be allowed only when the connection is symmetrical and contains at least four rivets. The bending at the heel of connection angles must be considered, as well as the bending on the part to which the detail is attached. When $\frac{7}{8}$-in. rivets are used, the connection angles should be $\frac{5}{8}$-in. metal and the gauge of rivets 2 in. With $\frac{3}{4}$-in. rivets use $\frac{1}{2}$-in. angles and $1\frac{3}{4}$-in. gauge. Additional rivets must be provided to take any shear coming on the same connection."

It is not clear why lacing systems should be required to take a shearing stress of $2\frac{1}{2}\%$ of the direct load of a compression member. There is no possibility of a member having so great a shear, if it is even approximately straight. Two causes are possible that may give a transverse shear on a compression member, one of which is the weight of the member, and the other is a bow in the axis of the member.

Assuming that, on the basis of the direct stress, the gross area including rivet heads and lattice bars would have 8 000 lb. per sq. in. compression. The weight of each square inch would be 3.4 lb. per ft. and in order to have a

weight of 1% of the stress, in one-half the length of the member, or an end shear of that amount, this one-half length would be about 23 ft. This member would then have a cross-shear, due to its weight of approximately 1% of the direct stress, only when the length is about 46 ft. This percentage of shear would exist only in very long members, from this cause, and special provision would be made for the weight of such members, if latticed.

If the bow of a presumably straight member was $\frac{1}{400}$ of its length, assuming a parabolic curve, the shear due to the curve, near the ends, would be 1% of the end load. A bow of this amount, 0.3 in. in a column 10 ft. long and 0.6 in. in a column 20 ft. long, would be observable and a cause for rejection. Certainly, a bow of 1.5 in. in a 20-ft. column, which would be the condition to give 2½% of shear, would be cause for alarm. There appears to be no good reason, therefore, for requiring lattice systems to be designed for more than about 1% of the direct load, in transverse shear.

The rule for net area of a tension member, Article 327, seems to be new. It seems to be purely empirical and is too severe and wasteful. The writer made a series of tests,* which seemed to show clearly that the minimum net area of a bar measured on a zigzag line, joining rivet holes, is the measure of the value of the bar in tension. Opportunity was afforded to bring evidence to controvert this, but no such evidence was furnished. Tests on riveted seams were cited, but a riveted seam in which the stress originates in the rivets, is quite different from a bar or flat, in which the stress is axial and merely distributes itself around holes cut out of the section.

There seems to be a conflict between Articles 905 and 1401 on the strength of full-size eye-bars in tests. The latter requires 1 000 lb. per sq. in. more in both yield point and ultimate strength.

D. B. STEINMAN,† M. AM. SOC. C. E. (by letter).‡—The Tentative Specifications submitted by the Special Committee contain many features meriting commendation; but in a number of points of outstanding importance, the Committee has disappointed the Profession by failing to make an advance over existing specifications.

Unit Stresses.—The specified unit stresses are entirely too low. In fixing unit stresses for design, the safe stress for dead load should govern. A basic unit stress of 20 000 lb. per sq. in. would leave ample margin below the elastic limit, and would unquestionably be safe for dead load. Providing for dead load stress at 16 000 lb. per sq. in. is a waste of metal. Years ago, Cooper established 20 000 lb. per sq. in. as the working stress for dead load, and the advance since then in the structural art should justify a reduction and not an increase in the "factor of ignorance."

The difference between the effect of live load and that of dead load should be taken care of by the impact allowance and not by a reduction in working stress. If 20 000 lb. per sq. in. is a safe stress for dead load, it is also a safe stress for live load plus impact.

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* *Engineering News,* May 3d, 1906.

† Cons. Engr., New York City.

‡ Received by the Secretary, February 2d, 1922.

The provision for future increase in live load should be made by assuming a heavier live load, and not by reducing the working stress. To provide for probable increase in loading by using a reduced working stress is illogical and results in an unbalanced design. The live load may increase, but the dead load will not; as a result, the bridge members carrying the largest proportion of dead load stress will be the most extravagantly designed, and the members carrying the largest proportion of live load stress will be relatively the most deficient in section. It cannot be disputed that exactly the reverse condition ought to be the objective in proper design. To secure the largest possible margin of strength for increasing loads, with a minimum expenditure of metal, the extra metal should be distributed among the various members in proportion to their live load stresses. Accordingly, the most economical and best balanced design will be secured by adhering to the principle previously enunciated, namely, the provision for future increase in live load should be made by designing for a heavier live load, and not by reducing the working stresses.

The writer maintains that the working unit stress in tension should be at least 20 000 lb. per sq. in. instead of 16 000 lb., as proposed in the Tentative Specifications. The other proposed unit stresses should be increased in the same ratio.

Live Load.—It is disappointing to have the Committee dismiss the important question of live load in so summary a fashion, and to retain the ancient Cooper loading in the proposed specifications.

Cooper's loading does not correspond to modern locomotives, and its retention as a standard for design is unscientific. Its use produces designs that are unbalanced for modern loadings. For instance, the Pennsylvania Railroad N 1 S locomotives are equivalent to Cooper's E-55 for some bridge members and to Cooper's E–76 for others, a range of variation of 38 per cent. The Erie 2–10–2 locomotives are equivalent to Cooper's E–53 for some bridge members and to Cooper's E–70 for others, a range of variation of 32 per cent. Other locomotives, compared by the writer, gave similar ranges of variation. In other words, structures designed for the arbitrary Cooper's loading will not be of uniform strength for a given modern locomotive; some of the members in a span will be defective in strength, and some of the spans in a line will be disproportionately weak, in comparison with others, and this difference in strength may be as much as 30 or 40 per cent. A loading that yields such disproportionate results may well be regarded as obsolete. A Cooper engine diagram does not represent modern locomotives and should not be used for designing modern structures.

An argument advanced for retaining Cooper's loading is that it affords a convenient standard for rating bridges; but the writer maintains that a standard that has become warped to such an extent as to yield results that fail to harmonize by 30 to 40% has outlived its usefulness. A new loading, in the form of a diagram, formula, or chart, should be developed for these specifications. This loading should satisfy the following requirements:

1.—It should give results that harmonize closely with the stresses producible by modern heavy locomotives.

2.—It should be heavy enough to provide for the probable future increase in loading during the desired life of structures. Accordingly, it should be 25 to 50% heavier than the average present loading (supposed to be represented by E–60).

3.—It should be presented in such form as will yield maximum facility of application and will discourage meaningless refinement of computation.

The writer has been giving his spare time to the development of a new loading diagram along the foregoing lines, and he hopes to be able to submit the results of his studies to the Profession at an early date.

Impact.—In past American practice, there have been two different types of impact formulas:

1.—Formulas based on the ratio of live load stress to live plus dead load stress, $\frac{L}{L + D}$.

2.—Formulas based on the length (l) of load producing the stress.

The writer is convinced that formulas of either class are only partly correct; and that to be truly scientific and comprehensive an impact formula should combine both the factors enumerated. In other words, a term of the form, $\frac{L}{L + D}$, should be incorporated in the impact formula.

The inclusion of this factor will make automatic correction for the greater inertia resistance of the heavier sections in a given structure and of the heavier structures in a given line. It will apportion the largest relative additional metal for impact to those members in which the live load bears the largest ratio to the dead load, thus contributing to the longevity of the structure under increasing loads. It will yield results conforming to the principle that impact should be less on bridges with solid ballasted floors than on those with open decks. It will yield a reduced impact for bridges carrying a highway floor in addition to the railway tracks. It will be a partial compensation or incentive for adopting the heavier and more rigid construction in a choice between alternative designs. It will automatically increase the impact tax on very short spans and reduce it on very long spans. Moreover, it will yield a formula applicable without change to all types of structure on a line, instead of requiring different formulas to be used for steel trusses, concrete arches, etc.

The formula recommended in the Tentative Specifications is defective in that it makes no distinction between light and heavy constructions of the same length of span; for instance, it would yield the same impact stresses for bridges with solid decks as for those with open floors. This defect would be remedied, and the other advantages enumerated previously would be secured, if the impact formula was corrected so as to include the factor, $\frac{L}{L + D}$.

The revised formula, moreover, should conform with observed effects by yielding impacts exceeding 100% for very short spans. Accordingly, the

writer would propose the following formula for impact percentages so as to combine the two contributing factors of load length and load ratio:

$$I = \frac{200}{100 + l} \times \frac{L}{L + D}.$$

The values yielded by this formula for open-deck spans of various lengths conform closely to the maximum impact percentages recorded in the American and the English tests. This is shown by Fig. 17, where the graph of impact values calculated by this formula (for open-deck spans), practically coincides with the highest test values recorded from all lengths of spans. For solid-deck spans, the impact values yielded by this formula are appropriately lower.

The formula is simple, easy to apply, and, in the writer's opinion, more scientific and comprehensive than the formulas proposed.

Column Formula.—The Committee should decide on the column formula to recommend, instead of complicating matters by offering the designer his choice of three different formulas.

The conditions do not warrant hair-splitting precision in fixing working stresses for columns, and there seems to be little justification for using quadratic formulas when a simple straight line formula gives essentially the same results. A straight line formula with a horizontal maximum should suffice.

One important point that has not been provided for in any of the standard specifications, is the difference in permissible stress in columns having different forms of open or closed sections. Closed or box sections are safer against buckling than open sections, and solid diaphragms or cover-plates are more effective than planes of latticing. This difference in value of different forms of section should be represented in the column specification. The column formula should allow a higher working stress for the sections that are known to be safer, so as to offer a premium for the selection of the more substantial designs, instead of encouraging, as the present specifications do, the adoption of open, flaring sections for the sake of economy.

On the basis of a working stress of 20 000 lb. per sq. in. for tension, the writer would recommend that the following working stresses be specified for columns:

For a closed section, or a section with two diaphragms, or a section with one diaphragm and two planes of lattice:

$$22\,000 - 100\,\frac{l}{r} \text{ (maximum, 20 000).}$$

For a half-open section with one cover-plate and one plane of lattice, or a section with one diaphragm without latticing:

$$20\,000 - 100\,\frac{l}{r} \text{ (maximum, 18 000).}$$

For an open section with two or more planes of lattice:

$$19\,000 - 100\,\frac{l}{r} \text{ (maximum, 17 000).}$$

The writer maintains that the adoption of such specifications for column design will be conducive to better and more consistent designing.

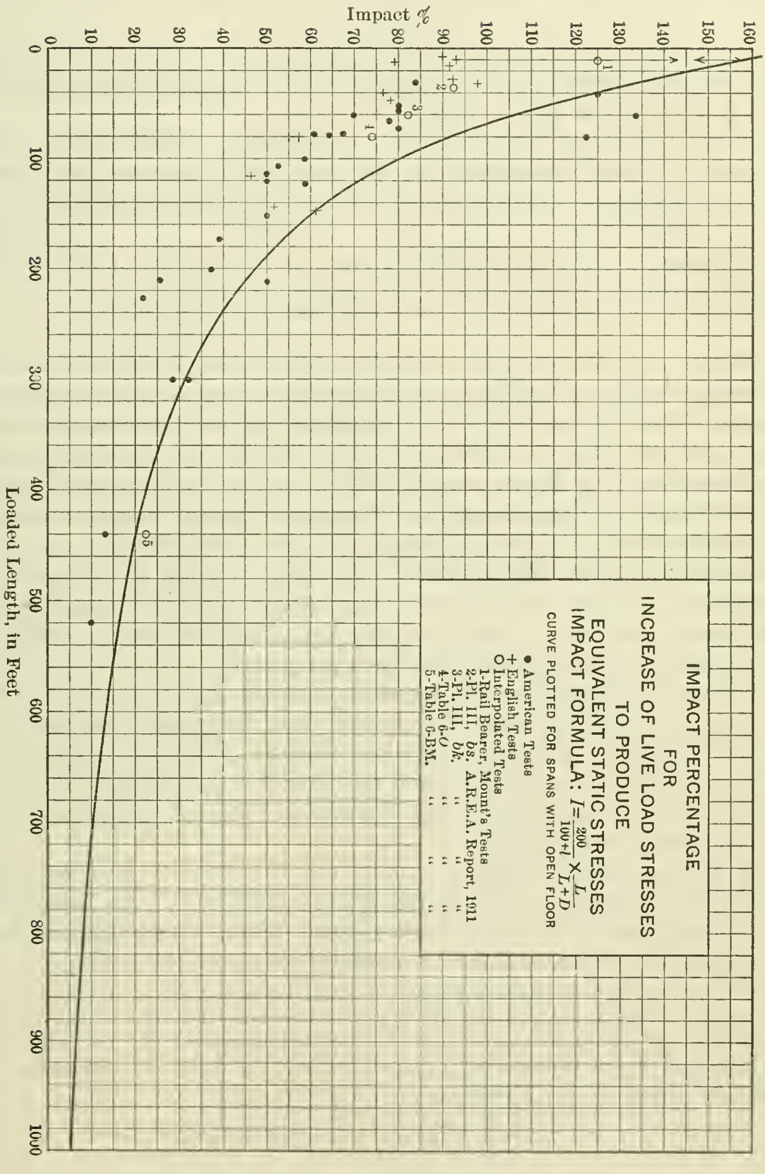
IMPACT PERCENTAGE
FOR
INCREASE OF LIVE LOAD STRESSES
TO PRODUCE
EQUIVALENT STATIC STRESSES
IMPACT FORMULA: $I = \frac{200}{100+l} \times \frac{L}{L+D}$
CURVE PLOTTED FOR SPANS WITH OPEN FLOOR
● American Tests
+ English Tests
O Interpolated Tests
1-Rail Bearer, Mount's Tests
2-Pl. III, bs. A.R.E.A. Report, 1911
3-Pl. III, bk. " "
4-Table 6-O " "
5-Table 6-BM. " "
Impact %
Loaded Length, in Feet

Fig. 17.

If, in addition, it is desired to include in the column formula the extreme fiber distance, c, as urged by Mr. Leffler,* the writer would suggest that the term, $100 \frac{l}{r}$, in the formulas previously mentioned be replaced by a term:

$$80 \frac{l}{r} \frac{c}{r}.$$

Of the minor points in the specifications, the writer has noted several on which some questions may be raised.

Spacing of Trusses.—Past practice has required a width between centers of trusses of about one-sixteenth of the span, and it seems to be a step in the wrong direction to reduce the prescribed width to one-twentieth of the span.

Pin Stresses.—The safe bending stress in extreme fibers of pins is better represented by $40\,000 - 1\,000 \frac{l}{d}$, than by a flat value of 24 000.†

Reversal of Stress.—Except for the connections, there is no physical justification for the reversal clause, requiring an increase in section for reversal of stress. It has been defended as a disguised method of increasing the sections of web members for prospective load increase; but this object ought to be accomplished in a direct, straightforward manner by designing the structure for the probable future loading. The greater impact on web members is fully provided for in the impact formula proposed by the writer.

Combined Stresses.—With a basic unit stress of 20 000 lb. per sq. in., the augmentation of the working stress for a combination in which lateral and longitudinal forces are included, may be 20%; and if secondary stresses are also included, the augmentation may be 30 per cent.

Overload.—With a basic unit stress of 20 000 lb. per sq. in., it is assumed that the design load is about 25% higher than the present loadings. Consequently, only 25% increase in live load need be considered in the overload clause. In addition the clause should stipulate that any reversal of resultant stress that may be caused by a 25% increase in live load, should be provided for in the design of the member.

Net Sections.—The proposed formula can be shown to give inconsistent and anomalous results. In 1920, the writer submitted, to the Bridge Engineers' Committee of the New York Central Lines, a specification derived from theoretical considerations and confirmed by experimental results:

"The net section of riveted members shall be the least area which can be obtained by deducting from the gross sectional area, the area of holes cut by any straight or zigzag section across the member, counting the full area of the first hole and a fractional part of each succeeding hole, the fractional part being determined by the formula,

$$1.3 - \frac{P}{G} \text{ (but not to exceed unity)},$$

where P is the pitch (longitudinal) distance, and G is the gauge (transverse) distance from the preceding rivet."

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 730.

† See the writer's article, "Higher Stresses for Bridge Pins", *Engineering News-Record*, March 24th, 1921.

As an illustration, consider a chain of five rivets in a diagonal line, with spacing between the rivets of 2 in. pitch and 4 in. gauge. By the Tentative Specification, only $1\frac{1}{2}$ holes need be deducted; by the writer's rule, 4.2 holes should be deducted. The latter result agrees exactly with the value given for this example by the theory of combined stresses.

In conclusion, the writer would urge a more thorough discussion and consideration of the Tentative Specifications, as there is little to be gained by a hasty decision on the larger questions involved.

PERCIVAL S. BAKER,* M. AM. SOC. C. E. (by letter).†—The writer has studied the Tentative Specifications and would offer the following criticisms:

Article 12.—The specifications of the Philadelphia and Reading Railway Company, provide for a minimum width between center of trusses of one-fifteenth of the span, which appears to be better than one-twentieth as given in the Tentative Specifications, since the greater width would tend to make the span stiffer against lateral deflection. The limiting value, however, is largely a matter of personal opinion.

Article 15.—It is stated in this Article that ties should be dapped $\frac{1}{2}$ in. over the lowest part of the girder. This should be modified to give the maximum depth of dap allowed, preferably $1\frac{1}{8}$ in., in order to avoid excessive notching. The attachment of ties to girders or beams is unnecessary and a needless expense, as it has been the writer's experience that such fastenings are inefficient; it is now the practice to provide no fastenings of this character, depending on the dapping of the ties over the girders for alignment and the wooden guard-rails for the prevention of bunching. The writer would suggest that some qualifying phrase be added in regard to spacing ties at the floor-beams in order that top flange of the floor-beams may be kept clean.

Article 106.—The proposed impact formula, when compared with the Pencoyd formula, which has been largely used during recent years, increases the impact only a small amount on spans of less than 100 ft., but on spans of more than 100 ft. the decrease is marked, amounting to 6% for a 150-ft. span and 20% for a 300-ft. span. Since the longer spans are more expensive to build and harder to renew, they should have a longer life, and, therefore, the proposed reduction of impact for the longer spans does not seem desirable; also, there is only a small compensation in the increase for the shorter spans. A more desirable formula appears to be:

$$I = 125 - \frac{1}{8}\sqrt{2\,000\,L - L^2},$$

which follows the tests closely, increasing the impact considerably on the shorter spans and not decreasing it so much on the longer spans, when compared with the Pencoyd formula. In the writer's opinion, the formula,

$$\frac{300}{300 + \frac{L^2}{100}}$$

* Engr. of Bridges and Bldgs., P. & R. Ry., Philadelphia, Pa.

† Received by the Secretary, February 4th, 1922.

proposed by the Committee, is not as good as the Pencoyd formula, but the formula,

$$125 - \frac{1}{8}\sqrt{2\,000\,L - L^2},$$

is better.

Article 201.—As all the formulas in common use agree well with tests, within the limits allowed in good design, there seems to be no good reason for departing from the straight line formula adopted by the American Railway Engineering Association in 1906 and 1910, namely, $16\,000 - 70\,\frac{l}{r}$, and which has been widely used. The writer would place the upper limit about 13 300, which would correspond with an $\frac{l}{r}$ of 40.

Article 306.—A greater value should be allowed for an angle connected by lug angles than for one connected by one leg only.

Article 603.—This Article is indefinite. A limiting percentage should be fixed, below which the ratio of the area of the flange angles to the total flange area should not fall.

Article 605.—The requirement, that a cover-plate should extend beyond the theoretical end a distance sufficient to develop the plate, seems to be excessive, as the full value of the plate is not required at that point.

Article 707.—Theoretically, this is a good requirement, but somewhat difficult to carry out. It should be left for the purchaser to indicate the method to be followed, if he should desire that such provision be made.

H. T. Welty,* M. Am. Soc. C. E. (by letter).†—The Tentative Specifications for Steel Railway Bridges, is, in general, a most excellent specification. The striking feature is the resemblance to the Specifications for Steel Railway Bridges, 1920, of the American Railway Engineering Association. The agreement between the two is so close that the arrangement and even the wording of the greater part of the Tentative Specification is identical with that of the A. R. E. A. Specification. The writer finds no fault because of this, but the question naturally arises, was there any reason for the production of this specification, and is there any excuse for its existence? To be sure, the wording of the A. R. E. A. Specification has been slightly changed in places, sometimes for the better, sometimes for the worse, but the two documents still remain essentially identical. The A. R. E. A. Specification was prepared, after several years of work, by a large and representative committee, made up principally of railroad bridge engineers. Undoubtedly, the railroad bridge engineers of the United States will use it, if they use either. Who then will use the Society's specification? Possibly electric railway or industrial companies, but, even this, is doubtful; and even so, would this be sufficient justification for the publication of an essentially identical specification under a different name. It seems to the writer that the most graceful and the most useful action the Society could take, would be the endorsement of the A. R. E. A. Specification, with such suggestions for revision as might seem desirable.

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* Engr. of Structures, N. Y. C. R. R., New York City.

† Received by the Secretary, February 4th, 1922.

Referring to the Tentative Specifications in detail, the following comments are offered:

Article 15.—It is impracticable always to dap ties $\frac{1}{2}$ in. Some girders have a number of cover-plates and to follow this rule strictly would require ties at as many depths as there were cover-plates. A maximum allowable depth of dap should be specified, about $1\frac{1}{4}$ in. or $1\frac{1}{2}$ in.

It would seem undesirable to go into too much detail as to methods of preventing the bunching of ties. This should be left to the judgment of the Engineer. A recently developed method of preventing ties from bunching is the use of small spacing blocks between the ties at each end.

Article 16.—The special load of 15 000 lb. per lin. ft. applies only to transverse beams spaced close together. This distinction should be made.

Article 108.—As written, this article has no force. An increase of 50% in the live load could not produce the same increase in the total unit stress, unless there was no dead load stress. For members other than counters, the percentage of increase would be considerably less than 50%, the amount depending on the ratio of the dead load to the live load with impact.

The corresponding article in the A. R. E. A. Specification was introduced to require the provision of sufficient excess section in the web members (which have a comparatively low dead load stress), so that, under maximum overload, all members in a truss would be stressed uniformly. It was based on the assumption that the average dead load stress in the chords is one-half the live load stress with impact. An increase of 75% in the live load would produce, in such chords, an increase of 50% in the total unit stress, which was considered the point of maximum overload.

Article 112.—Although it may be desirable to give the formula for computing the centrifugal force, there seems to be no good reason for omitting the tabulated percentages given in the A. R. E. A. Specification. This tabulation saves considerable effort on the part of the designer.

Article 201.—After a Conference Committee, composed of representatives of the Society and the American Railway Engineering Association, had agreed on a column formula, it was hoped that this question had been settled for some time.

The Committee, however, has seen fit to open up the question again by injecting three different column formulas in its specification. This will simply lead to confusion and will not promote desirable uniformity of design.

It is also noted that the permissible shear in plate-girder webs is given as 10 000 lb. per sq. in., net section. This seems to be unnecessarily low.

Article 328.—Apparently, the word, "area", should read "diameter".

Article 504.—Why is sway-bracing specified only in the planes of the end-posts of deck truss bridges? Surely such bracing is as necessary at intermediate points in such spans as in deck plate-girder spans.

Article 703.—Trusses should be cambered for the sum of the dead load and live load deflections. If for dead load only, the bottom chord, when erected, will be a straight line, but will have the appearance of sagging. Although this will not affect the strength it is displeasing to the eye. The writer recalls a case of a truss about 175 ft. in length, where, due to an error in detailing, camber was provided for dead load deflection only. Shortly after erection

was completed, alarm was felt in some quarters, due to the apparent sag in the bottom chord, although this chord was absolutely straight.

Article 706.—Apparently the word, "thick", has been omitted at the end of the Article.

A. W. Carpenter,* M. Am. Soc. C. E. (by letter).†—The Tentative Specifications for Steel Railway Bridges follow so closely the General Specifications for Steel Railway Bridges of the American Railway Engineering Association that it hardly seems proper to propose or consider them otherwise than a slightly revised edition of the latter specifications. Minor changes in the arrangement, wording, and, occasionally, in the substance of the clauses of the A. R. E. A. Specifications have been made, and, in some cases, improvement will perhaps be conceded, but other changes are matters of opinion on which no two committees of experts would ever agree. There are also some changes—minor like the others—which, in the writer's opinion, do not improve the A. R. E. A. Specifications.

No change in important principle, nor any change that would produce a materially different structure from those built under the A. R. E. A. Specifications is discernible to the writer. The following clauses may be commented on:

15.—Timber Floor.—There are several satisfactory ways of fastening and securing ties to the steelwork and there seems to be no necessity for specifying the detail of one of these. The A. R. E. A. Specification is superior in this and also in limiting the extent of dapping of ties, which has a weakening effect.

16.—Ballasted Floors.—The special live load specified is not necessary in the case of ballasted track carried on longitudinal beams with or without cross-beams, and should be limited to floors composed of closely spaced cross-beams, as provided by the A. R. E. A. Specifications. The load of 15 000 lb. per lin. ft. should also be variable to agree with the variations in live load permitted in Article 104.

18.—It is to be questioned whether end floor-beams are to be preferred. They add to the expense, make back-walls less accessible, are not practicable on ends more than slightly skewed, and the writer never found any necessity for them.

108.—Overload.—This specification differs from the A. R. E. A. provision for extra section in web members of trusses to take care of the increased live load without increasing the unit stresses disproportionately as compared with the chord members. The A. R. E. A. Specifications provide, in effect, for a 75% increase in live load without more than 50% increase in the specified unit stresses in web members. Ordinarily, chord members and end-posts of trusses up to a span of 300 ft. will carry a live load increase of 60 to 75% (varying with the length of the span), with an increase of not more than 50% in the designing unit stress. In order that the interior web members may not be stressed more than 50% above the designing unit stresses, with the increase in live load which would increase the corresponding chord unit stresses 50%, the web sections must be increased slightly, and it seems well to require this

* Asst. Valuation Engr., N. Y. C. & H. R. R. R., New York City.

† Received by the Secretary, February 7th, 1922.

as it adds comparatively little expense to the structure. The A. R. E. A. Specifications provide for the extreme case of 75% overload. By providing for an overload in interior web members equal that which the chords will carry with the same 50% increase of designing unit stress, the desired end would be attained in perhaps the most satisfactory manner.

109.—Lateral Forces.—The distance of 8 ft. above the base of rail for center of application of the lateral load, representing the "nosing effect" of the locomotives, is too high. Centrifugal force is taken at 6 ft., which corresponds more closely to the height of the center of gravity of the locomotive, and it would appear that the same figure should be adopted in both cases. The A. R. E. A. Specification is the same as the Tentative Specification in this respect.

111.—This article provides an addition to the A. R. E. A. Specification, which appears to be an improvement.

112.—Centrifugal Force.—There is argument for showing the formula, but the speed factor must be determined. Practically, the speed depends on the curvature and the A. R. E. A. table showing the centrifugal force for varying degrees of curvature at the corresponding speeds which have been adopted generally as the maxima allowable, has been found far more convenient for use than the general formula. This table saves time and avoids error in the determination of this force. In any case, the usual limiting speeds in miles per hour to be used with different degrees of curvature, should be provided, as, otherwise, this information would frequently have to be estimated.

Column formulas worry others more than the writer. He sees no occasion for formulas more complicated than the "straight line" formula. There is, however, one thing in connection with column strength, which the Committee perhaps has not considered and which might make a worth while subject of investigation, that is, the effect of impact on columns and compression members. The horizontal "cut-off" of the column formula for low ratios of length to radius of gyration is probably all right for static loads, but for impact it is questionable. The impact effects, as the writer conceives them, are momentary in their extremes. It requires time as well as load to cause a compression failure. The case may well be similar to that of timber beams as noted hereafter. It may be different with a tension member. To take care of this feature the amount of impact could be made less for compression members than for tension members although retaining the respective working unit stresses proposed. It seems likely that compression members of ordinary truss bridges are being made disproportionately heavy on this account, and if the Committee could determine this to its satisfaction, and propose a change in the specifications accordingly, it would be one really new suggestion of importance in the science of bridge design.

201.—Relative to tension in extreme fibers of timber of two groups: The working stresses shown are apparently intended to be used exclusively for timber ties with bending moments produced in practical entirety by live load increased 100% for impact. For such application and conditions, they are conservative; but it might be well to note the intended application and conditions directly in Article 101, for the stresses are too high for static loading. It also seems reasonable to think that the impact on ties might be reduced to

50% for electric traction in accordance with the provision in Article 107 for reducing by one-half the impact computed by the formula of Article 106. The Committee on Timber of the American Society for Testing Materials reported, in 1921, in reference to working stresses in structural timber beams, as follows:

"It is also well determined by the tests that resistance to suddenly applied loads is much greater than to slowly applied or constant loading; therefore, the condition of loading will affect the amount of allowable stress";

and, also,

"From the above it will be seen that in order to have a rational design it is necessary to state working stresses of different amounts for different kinds of loadings and exposure of timber. As an example, for dense structural yellow pine, the maximum working stress will be 1 100 lb. per sq. in. This is for constant loading and for submerged locations where the timber is constantly wet. In locations in the weather, such as bridges, the allowable working stress for constant loading is 1 400 lb. per sq. in. Under cover, where the timber is always dry, the allowable working stress for constant loading is 1 600 lb. per sq. in."

Also,

"From the tests, it is determined that the resistance of timber is approximately proportional to the speed of loading. For constant loading, the stresses above given are proper, but for sudden loading, resulting in 100% impact, the successive loadings being far enough apart so as to allow reasonable recovery of the timber, the allowable stresses may be doubled (not to exceed 2 800 lb. per sq. in.), the stresses due to this sudden loading being those actually computed from the load with the impact. For other proportions of impact, less than 100%, the allowable working stress may be increased in a ratio equal to the percentage of impact. For dense structural yellow pine, the allowable working stresses would, therefore, be as follows:

1. For wet or submerged locations... $1\,100 + 1\,100\,I$ lb. per sq. in.
2. For exposed locations (bridges)... $1\,400 + 1\,400\,I$ " " "
3. For constantly dry locations...... $1\,600 + 1\,600\,I$ " " "

where I is the proportional impact stress."

These quotations from the report of the A. S. T. M. Committee, are given here because the writer (who is in no way connected with the Committee) believes it to be the most rational exposition of the subject he has seen and that it points out the proper method of specifying working stresses for timber, although the constants of the impact factors seem rather high. It will be noted that the A. S. T. M. Committee would allow, for dense structural yellow pine, 2 800 lb. per sq. in. (fiber stress in bending) for live loads with 100% impact, 2 100 lb. per sq. in. with 50% impact, but only 1 400 lb. per sq. in. for all dead load or a sustained live load without impact.

703.—Camber.—Why should the camber be equal to the deflection produced by the dead load only? The A. R. E. A. Specification requires it to equal the combined dead load and live loads without impact, which seems proper, as it seems undesirable that the structure should sag, or curve downward under live load.

1202.—Painting of Surfaces in Contact.—The writer thought that coating with linseed oil was a practice that had been outgrown. It is certain that a coating of linseed oil without pigment has neither the durability nor protective qualities of one of linseed oil mixed with pigment to form a suitable

paint. The difference in thickness of a thin paint coating and one of linseed oil without pigment is too little to offset the deficiencies of the latter otherwise.

The writer believes that the report of the Committee, of which the Tentative Specifications form the principal part is a general endorsement of the A. R. E. A. Specifications for Railroad Bridges and shows that the Committee finds no need for another set of general National specifications for this class of structures. Instead of taking the work of its fellow Society, modified to such a slight degree as in this case, and presenting it as a different product and the production of this Society, it would seem that the courteous and just thing to do is for the Society to endorse the A. R. E. A. Specifications, with a statement of the few minor points of exception, which should apply to substance only, and could be listed briefly.

Benjamin W. Guppy,* M. Am. Soc. C. E. (by letter).†—The existence of this Committee is evidence of a desire on the part of some members to have the Society sponsor some kind of a specification; but what kind, a working specification or a general specification? A working specification is necessarily narrow. It is a definite set of rules issued by the purchaser in order to obtain the kind of a bridge he wants. It is a part of the contract. It should not be used in Court, except as evidence of what is required under the contract. When prepared by an individual, it is the embodiment of his personal predilections; when prepared by a committee, it is usually a compilation of compromises and is subject to modification by the individual user. A general specification, on the other hand, should be broad. From it the purchaser should be able to draw the necessary inspiration and information to enable him to prepare a working specification for any kind of a bridge at any location. It should furnish the information which would enable a user to determine the maximum safe carrying capacity of his structure, in so far as it is possible to do so. It should be capable of being used in Court as a guide in determining right and wrong in bridge design.

The construction of any bridge requires a minimum expenditure to secure the requisite service and security. Additional expenditures, to obtain increased strength and rigidity, to facilitate maintenance, and to minimize the effects of accidents, are optional with the purchaser. Moreover, the cost of the bridge superstructure is only one unit in the cost of the project and should be balanced against all other items of cost, in order to obtain the total minimum expenditure. All of which should be recognized and provided for in a general specification.

The Committee has presented for discussion, a draft of what appears to the writer, to be a working specification, a specification for which there does not appear to be any necessity. The writer believes that if the Society is to issue a bridge specification, it should be a general specification. Moreover, every article should be followed by an explanatory statement showing how it is derived, what it is expected to accomplish, its relative importance and necessity, and what other methods can be used to secure equivalent results.

The following discussion of some of the articles of the Tentative Specifi-

* Engr. of Structures, Boston & Maine R. R., Boston, Mass.

† Received by the Secretary, February 15th, 1922.

cations is an attempt to show why the writer believes they are too narrow in their scope, why some of the requirements now obligatory should be optional.

10.—Span.—What is the necessity of recommending limiting span lengths? Why not state limiting conditions instead? The maximum span for I-beams is determined by three factors: Loads, unit stresses, and section moduli. Their use is determined by these three factors plus relative economy. The purchaser should have the option of substituting built sections for I-beams, in order that the work may not be delayed, or for any other good reason, hence there is no minimum limit for plate girders. The maximum span for plate girders is determined by weights and dimensions that can be handled and shipped to the site, the question of relative economy always being considered, and this includes annual cost as well as first cost. As between riveted and pin trusses, it is a question of economy, rigidity desired, and local conditions controlling erection.

11.—Number of Trusses.—The proper number of trusses or girders for a multiple-track bridge is a question of economy, as governed by local conditions.

104.—Live Loads.—The use of the Cooper series of engines should be continued for well-known and oft-repeated reasons. The proper E value to use is a matter for individual judgment, based on past experience and an estimate of future traffic development. It is good judgment to use an E value in excess of the equivalent E values of the heaviest engines in service. A recommended percentage of excess could be stated. The Committee could also recommend the proper E values for use on different classes of roads.

201.—Unit Stresses and Section 9.—Materials.—Article 201 and Section 9 give the appropriate unit stresses to use with different grades of materials and specifications for these materials. The relation between the various stresses should be such that a bridge will be obtained of uniform strength throughout. Would it not be practicable to write all stresses as functions of T, the axial tensile stress, and then specify the appropriate values of T for the different grades of material.

337.—Expansion Bearings.—The object of hinged shoes is to reduce secondary stresses induced by deflection of the bridge or tipping of the masonry and to prevent the eccentric application of reaction due to deflection of the bridge. If the ends of girders are properly designed with sole-plates of the minimum size necessary to meet the specified stress for bearing of metal on metal, the displacement of the end reaction due to deflection will have no serious results. This Article is a combined accident and life insurance clause. The requirement is not a necessity as has been proved by the long and successful lives of a large number of bridges not equipped with pin shoes.

The writer believes a minimum span length of 100 ft. is sufficient, except for very shallow or very heavily loaded girders, when a limiting span length of 80 ft. can be specified.

341.—Inclined Bearings.—What valid objection can there be to allowing a short-span plate girder to slide on a plane parallel to the grade instead of on a horizontal plane. If the bridge is on a grade, something must be beveled, if there are no pin shoes. It is simplest to put the bevel in the bed-plates. Suppose the sole-plates are beveled as specified and the bridge arrives wrong

end to; it will be necessary to go to a wye or turn-table, or laboriously turn the girder at the site; or suppose, as has happened, it is discovered at the site that all the shoe-plates have been riveted up with the thick ends at the ends of the girders. On the other hand, if a casting has been incorrectly placed, it is easy to jack it up and reverse it.

Articles 606, 611, and 612.—These Articles are intimately related. If the distance between flange angles is less than the value obtained from Formula (c), Article 611, and Article 309, "Limiting Thickness of Metal", is observed, why the necessity of the additional requirement of Articles 606 and 612? Why the arbitrary minimum thickness of web specified in Article 606? How are Articles 606 and 612 derived? How is the maximum safe carrying capacity of a girder web determined? Given thickness and depth of web, spacing of stiffeners, and clear distance between flange angles, the allowable web shear unit stress is determined from Formula (c), Article 611, increased by a specified percentage and the live load calculated by working backward from the allowable maximum shearing stress. How much consideration should be given to the requirements of Articles 606 and 612 in obtaining maximum capacity? Is an engineer guilty of negligence if he allows loads on a girder the web of which fills the requirements of Article 611, but which fails in regard to Articles 606 and 612?

These are only a few of many paragraphs that can be criticized, but they are sufficient to illustrate the writer's viewpoint.

G. G. THOMAS,* ESQ. (by letter).†—The 1910 Specifications of the American Railway Engineering Association for the design of steel railway bridges are being used by the writer's Company, and at the present time it is the intention to continue using these specifications, because it appears that impact and compression formulas are in a transition state. Since the 1910 A. R. E. A. Specifications appear to give more economical spans than either the 1920 A. R. E. A., or these Tentative Specifications, it is the intention to continue using the former.

The principal reasons for adhering to the 1910 Specifications are:

First.—The impact allowance called for is less for spans of 100 ft. and under than in the 1920 Specifications; this will represent a saving in tonnage, as the Company's bridges are, as a rule, plate-girder spans. The impact allowance in the 1910 Specifications appears to cover amply the actual stresses caused by impact, as far as present experience and experiment show.

Second.—The compression formula and the limiting compressive stress allowed in the newer specifications will give heavier and, therefore, more expensive trusses than the older specifications.

In the Tentative Specifications, the writer notices the following:

15.—Timber Floor.—This Article calls for hook-bolts. The practice of the writer's Company is to use plate-washers not less than 5 in. square for securing the wooden floor to the stringers or girders, as hook-bolts soon work around in wooden ties and become ineffective.

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† Received by the Secretary, February 14th, 1922.

108.—Overload.—Observation of this requirement would be desirable in truss design, as it should be ample to take care of increase in live load for the usual life of metal bridges.

206.—Combined Stresses.—It is suggested that this Article be made to read "so that the combined fiber stress will not exceed the allowed axial stress".

Section 6.—Plate Girders.—No provision seems to have been made for camber in plate-girder spans. The writer believes such provision should be made, especially for long swing bridges.

615.—Ends of Through Girders.—The writer would prefer the rounding of the ends of through plate girders, rather than the use of brackets on the ends of the girders, as the latter would not give a neat detail.

1202.—Surfaces in Contact.—It is the writer's practice to paint each contact surface with one coat of red lead and boiled linseed oil. The linseed oil alone would hardly be effective in the prevention of rust.

Charles Evan Fowler,* M. Am. Soc. C. E. (by letter).†—The writer feels considerable responsibility for the fiasco which has resulted from an attempt to write a real railroad bridge specification. The letter addressed to the Board of Direction by George H. Pegram, Past-President, Am. Soc. C. E., J. E. Greiner, M. Am. Soc. C. E., and the writer, in 1918, contemplated a committee to co-operate with the Committee of the American Railway Engineering Association, and other scientific bodies, in formulating a real joint specification. This was not carried out, and when the American Railway Engineering Association published its 1920 Specification of expediency and compromise, the writer signed the letter requesting the appointment by the Board of Direction of a committee to draft a real specification, or one which would represent the best in science and practice, to which the individual engineer could work and from which, in time, something worth while might result.

The Committee represents great individual ability, any member of which could write, over night, a specification better and more up to date than the one presented, which is only another one of expediency and compromise. If this is the best that can be done, then let the Society endorse the specification of the American Railway Engineering Association, and not clutter the records of progress with a production that will simply lead to confusion.

The fact is generally admitted that the Cooper loadings are out of date, and are only being retained as a matter of expediency. The adoption of a new system that is logical and that will distribute the metal properly, as between short and long spans, was shown to be feasible, by the writer,‡ in his paper on the "Revision of the Niagara Railway Arch Bridge." The Cooper loadings could still be used as a measuring stick, and it seems presumptuous to state that railroad operating officials could not understand such a change.

The matter of impact is certainly better provided for in the elliptical curve, but for a specification presenting the ultimate, it should also have factors for variable and critical speeds.

* Cons. Engr., New York City.

† Received by the Secretary, February 20th, 1922.

‡ *Transactions*, Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 1919.

With a proper loading, full allowance for impact, secondary, and all other stresses, modern unit stresses on a basis of not less than 20 000 lb. per sq. in. for structural steel in tension, should be adopted. The writer believes engineers should go even higher and make it possible for the railways to finance the replacement of large numbers of old and light bridges. The fabricating companies should see the advantage to them and join heartily in such a movement.

The adoption of a column formula must wait on a thorough study of all the recorded tests of columns. This can only be accomplished by a paid committee of two or three experts, and might be done as summer work by a sub-committee of the Committee.

There are many engineers who believe that such a study would result in the adoption of the Gordon formula, and this may be true. It may be found, however, that a straight line formula is practically correct; even if the formula adopted would prove as complicated as the secant formula, it need not frighten any one, for the unit stresses for various values of $\frac{l}{r}$ can be tabulated.

The members of the Committee, however, know all these things and much more. Will they rise to their opportunity and formulate a specification that will be the superior limit for the next quarter of a century, or will they perpetrate another report that will enlarge the slough into which committee work has fallen?

Frederick E. Schall,* M. Am. Soc. C. E. (by letter).†—The writer desires to express his appreciation, first, to the Society for appointing a Special Committee on Specifications for Bridge Design and Construction, and, second, to the Special Committee for presenting Tentative Specifications for Steel Railway Bridges so promptly after its appointment.

The large amount of capital expended each year warrants the most exhaustive investigation to produce specifications for the various kinds of bridges, issued and supported by the Society, the membership of which is vitally interested in having specifications under which good and lasting bridges may be constructed, specifications which may be universally used by the Profession.

In order to realize such results fully, it is the writer's opinion that a Joint Committee, representing those National engineering societies interested, should be organized to take up the preparation and completion of such specifications for the design and construction of bridges, as may receive the support of the largest number of engineers.

The Tentative Specifications for Steel Railway Bridges presented by the Committee follow, in a large measure, the "General Specifications for Steel Railway Bridges" for fixed spans less than 300 ft. long, adopted by the American Railway Engineering Association in 1920.

There are some points, both as to arrangement and description of details, in the Tentative Specifications that may be considered as an improvement.

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† Received by the Secretary, February 18th, 1922.

The following suggestions are made with regard to certain articles of the Tentative Specifications:

11.—Number of Trusses.—Four-track bridges may also be built with four trusses, to avoid disturbing the alignment of the two inside, usually main, tracks.

12.—Spacing of Trusses.—The minimum spacing of trusses or girders fixed at one-twentieth of the span seems to the writer not as good as the one-fifteenth fixed in the A. R. E. A. Specifications.

13.—Clearance.—The maximum super-elevation for bridges on curves fixed at 8 in. seems to provide sufficient clearance, but this figure should not be accepted as a proper one to use for the super-elevation of outer rails on curves for open-floor bridges, for which the super-elevation ought to be limited to, say, 6 in. maximum and the speed of trains reduced to suit such super-elevation.

15.—Timber Floor.—The words, "top of", should be added on the fourth line between "the" and "girder" to express properly what is meant.

101.—Weight of Materials.—Add, "ballast at 120 lb. per cu. ft."

With heavy rails, such as 135 lb. per yd., with tie-plates and steel guard-rails, the weight of rails and fastenings should be increased to 200 lb. per lin. ft. of track.

105.—Multiple Tracks.—The writer prefers the expression of percentage, as well as the amount of reductions, for loading multiple-track bridges given in the 1920 A. R. E. A. Specifications.

106.—Impact.—The impact formula of the 1920 A. R. E. A. Specifications should meet the requirements for open-floor bridges, except for spans of 25 ft., and less. For these short spans, a reduction of the unit stress of, say, 1 000 lb. per sq. in., such as was made in some of Cooper's specifications, might be adopted to good advantage, since short spans, stringers, etc., receive the severest usage under traffic.

For concrete ballasted floor bridges, for which a smaller impact than for open-floor bridges should be expected, a modified formula for impact should be incorporated in the Specifications, based on the necessary tests.

108.—Overload.—In order to obtain a properly co-ordinated structure under a 50% overload specified, a live load 50% greater, with impact, than is desired for normal conditions, coupled with proportionately increased unit stresses, might be used in determining the sections required for the various parts.

112.—Centrifugal Force.—The provisions for centrifugal force do not seem to be as complete and positive as those in the A. R. E. A. 1920 Specifications; the latter states the velocity of trains for various degrees of curves, and, therefore, should prove more satisfactory.

201.—The shearing unit stress in plate-girder and I-beam webs, if correctly stated at 10 000 lb. per sq. in., net section, seems considerably at variance with the A. R. E. A. Specifications, which allow a unit stress of 10 000 lb. per sq. in. gross section. The writer prefers the allowable unit stress based on net section, since this method tends to prevent the over-punching of web-plates.

308.—Strength of Connections.—It is suggested that this Article be amended to read:

"Connections carrying live load stress shall have a strength equal to that of the members connected, regardless of the computed stress. Connections for laterals and similar members may be proportioned for the calculated stress. Connections shall be made as nearly as practical symmetrical with the axis of the member."

310.—Pitch of Rivets.—The maximum spacing of rivets fixed at 7 in. for 1-in. rivets and 6 in. for ⅞-in. rivets, and twice the amounts given if rivets for angles are staggered in two gauge lines, does not seem to produce satisfactory results for the heavy materials used in modern railway bridges.

The writer's experience indicates that with a corresponding shorter spacing of 1 in., the members forming a section are not in all cases drawn together so tightly as to prevent water from entering between the angles and cover-plates of girders and other heavy sections.

318.—Built Tension Members.—The minimum length of stay-plates for riveted tension members should be specified.

337.—Expansion Bearings.—It is suggested that the length of spans requiring hinged and roller bearings be changed from 70 ft. to 80 ft. and more.

605.—Flange cover-plates need not be fully developed at the theoretical ends. The requirement of the A. R. E. A. Specifications of extending the cover-plates 18 in. beyond the theoretical length seems to be more consistent.

608.—Flange Splices.—Splices for flange members in long girders are generally necessary; the manner of such splicing should be described.

703.—Camber.—The camber equal to dead load deflections only seems too small. The A. R. E. A. requirements are more consistent with general practice and requirements.

801.—Bents and Towers.—To take care of bridges over streets, with single bents at the curbs, the last sentence of this Article should read:

"They shall usually be united in pairs to form towers, but where single bents occur, the columns shall have either hinged ends, or the columns and anchorage proportioned for bending due to horizontal forces and temperature stresses."

804.—Depth and Spacing of Girders.—At the end of this Article add "framed between and riveted to posts".

902.—Properties.—The yield point, in pounds per square inch, in the writer's opinion, should be fixed at 33 000, or at least made 32 500 which would be 50% of the upper limit of the tensile strength requirement.

940.—Excess.—The marginal heading should be changed from "Excess" to "Process".

1003.—Class of Workmanship.—The Committee should eliminate from this Article "(*a*).—Full punched and riveted work". For the main sections of railway bridges, sub-punched and reamed work, or drilled work, only, should be used, to assure the best results under the present bridge shop methods where tonnage output plays such an important part.

The writer hopes that the Committee, together with committees of other Engineering Societies, will extend its labors to the preparation of Specifications for the Design and Construction of Highway Bridges of Steel or Concrete. The need for such specifications under present-day highway traffic is

becoming more and more urgent, and the Society can be of real service to the public at large, by being instrumental in the production of such specifications.

P. G. Lang, Jr.,* M. Am. Soc. C. E. (by letter).†—The proposed Specification for Steel Railway Bridges of the Society should be considered in conjunction with the similar specification adopted by the American Railway Engineering Association. Comparison of these two specifications indicates that they are identical in all essential respects, such minor differences as exist are confined principally to phraseology, and concern no feature of major importance.

The use of the A. R. E. A. Specification as a guide in this class of work is practically general throughout the United States and Canada, and, in a varying degree, has extended to other parts of the world. It represents the labor of years and a consensus of professional opinion on the part of the country's largest purchasers of steel railroad bridges, and covers in complete detail the rules of practice the value of which has been demonstrated by experience.

The reason for the issuance by the Society of a specification identical with that of the American Railway Engineering Association is not apparent. It is, on the contrary, probable that such a step would be a source of confusion and inconvenience to purchasers of material of this class, especially those who are not constantly in the market. The adoption of a single specification, uniform standardization, and practice, with which fabricants, rolling mills, and designers could quickly familiarize themselves, would create a basis of absolute understanding, in each case, between the purchasers and the firm furnishing the material, concerning the character of material involved and the conditions on which the bid is to be made.

It would seem to be advisable to encourage the general adoption of the A. R. E. A. Specification now in effect, and that no steps should be taken by the Society toward the adoption of another specification to cover work of the character considered.

O. E. Selby,‡ Jun. Am. Soc. C. E. (by letter).§—A rather careful comparison, of the Tentative Specifications, with the General Specifications for Steel Railway Bridges of the American Railway Engineering Association, discloses no important differences. In this view, differences in wording without change of meaning are not important; differences in arrangement and sequence of identical matter are not important; differences of substance and requirements which are largely matters of individual preference, are not important; matters of controverted opinion which might be reconciled by an unbiased meeting of minds, are not important. It is the writer's opinion that all the differences between the two specifications can be placed in one or the other of these classes.

The work submitted by the Committee for the approval of the Society is not original work; it is merely a revision and an adaptation of the work of a committee of another Association. The Committee gives credit freely to the

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† Received by the Secretary, February 23d, 1922.

‡ Prin. Asst. Engr., C., C., C. & St. L. Ry., Cincinnati, Ohio.

§ Received by the Secretary, February 23d, 1922.

original source, and this statement is made without any derogatory purpose. The writer's purpose is to point out the futility and lack of dignity in the putting out of such a set of specifications by the Society. The creation of a special committee to cover the whole subject of bridge design and construction may have been justified, but the initial result which is merely the misbranding of another railway bridge specification, does not seem to the writer a good beginning. The Committee can hardly claim superior knowledge of the special branch of the whole subject here considered, and granting that—as it seems to do—the graceful course would be for the Society to pin its approval on the work of the Association with such specific reservations as might be initially desired.

The attitude of the Engineering Profession throughout the world should be considered. The wide acceptance abroad of the specifications of the American Railway Engineering Association, shows that foreign engineers are looking to American engineers for guidance in the matter of railway bridge practice. To an outsider looking for such guidance, the encountering of two "American" specifications, so much alike, would be confusing and hardly productive of respect for the two bodies involved.

As to the possibility of revising and reconciling the specifications: Knowing the history of the A. R. E. A. Specifications, and the attitude of the members of the committee which produced them, the writer can say that the need for revision is always present and that the suggestions of this Committee and others will receive cordial consideration. The ends of the Profession can best be served by such current revision, rather than by the adoption of the report of this Committee.

Because of the fundamental unsoundness of the proposal to adopt the Tentative Specifications, a detailed discussion of them would be out of place, but the writer cannot refrain from noting the absurdity of the offer of an assortment of column formulas in Article 201. The confession that the Committee is unable to agree on this minor matter is a confession of weakness in the whole work. It is not clear from the foot-note whether it is the intention to perpetuate the choice of column formulas or to settle on one formula after the discussion and before the final adoption of the specifications. In either case, the fact that both the Society and the American Railway Engineering Association are on record as having adopted a column formula—the work of a joint committee—should be given weight.

Because of his interest in the welfare and prestige of both the Society and the American Railway Engineering Association, the writer wishes to urge the withdrawal of the Tentative Specifications and the substitution of a report adopting the A. R. E. A. Specifications, subject to current revisions. The movement recently inaugurated by the American Engineering Standards Committee, to have these two bodies become sponsors for an American Standard Specification for Steel Railway Bridges, can be helped to a quick and happy conclusion by the action advocated.

WALTER S. LACHER,* ASSOC. M. AM. SOC. C. E. (by letter).†—A comparison of the Tentative Specification with the 1920 Specifications for the Design

* Associate Eng. Editor, *Railway Age Gazette*, La Grange, Ill.

† Received by the Secretary, February 27th, 1922.

of Steel Railway Bridges adopted by the American Railway Engineering Association, discloses a marked similarity. The two specifications are so nearly alike in form and substance that it is difficult to understand why it was necessary to issue the new instrument under the sponsorship of another society.

During the last twenty years the specifications for steel railway bridges adopted by the American Railway Engineering Association, have been accepted as the standard guide for the design and construction of steel bridges on American railways. The Committee on Iron and Steel Structures of the Association has come to be recognized the world over as the leading authority on this subject, and even in countries as remote as India, its work is given a great deal of consideration in the development of specifications. Because of this, the similarity in the two specifications, together with a duplication of words in the names of the two organizations, can only result in an unfortunate confusion.

It is conceded that the A. R. E. A. Specifications are not perfect. Some engineers are far from satisfied with certain features of the rules of design, particularly, the column formula. The method of determining the required section of the compression flange of plate girders also has been criticized, and a few bridge engineers have been disappointed because the specifications in their present form do not provide for the proportioning of bridge members for maximum loadings and maximum stresses. It is in reference to these specific features that the Tentative Specification differs in substance from the A. R. E. A. Specifications. The modifications proposed with respect to these disputed points may comprise distinct improvements over the corresponding requirements in the A. R. E. A. Specifications. Nevertheless, the writer believes that such improvement may be accomplished far better through action by the Committee responsible for the original specifications than through the agency of the Committee of the Society. That such changes or improvements may be forthcoming is evidenced by the fact that the report of the Committee on Iron and Steel Structures, for consideration at the next Convention of the American Railway Engineering Association, offers a new formula for the design of compression flanges of plate girders which is identical with the one embodied in the Tentative Specification.

The present rules for the design of steel railway bridges, as drawn up by the Committee on Iron and Steel Structures, are the result of a process of evolution. They represent years of work by the Committee and many hours of discussion at Annual Conventions. Through this process, they have undergone a gradual improvement and will continue to do so through the combined efforts of bridge engineers representing the railroads and other interests vitally concerned in this work. Any benefits to accrue from independent efforts on the part of others will be largely neutralized by unnecessary and confusing duplication.

J. B. Maddock,* Esq. (by letter).†—The writer regrets that he has not had an opportunity to study the Tentative Specifications in detail, but he notes that in the main features, such as loading, impact formulas, permissible unit

* Engr., Bridges and Buildings, Central of Ga. Ry., Savannah, Ga.

† Received by the Secretary, February 27th, 1922.

stresses, and quality of material, it is substantially in accord with the 1920 Specifications of the American Railway Engineering Association. As the latter specification is satisfactory to the writer, he has no criticism to offer.

F. AURYANSEN,* M. AM. SOC. C. E. (by letter).†—The Tentative Specifications differ from the 1920 Specifications for steel railway bridges with fixed spans of less than 300 ft. in length of the American Railway Engineering Association, principally in the title. As the 1920 A. R. E. A. Specifications are the expression, by American railroad bridge engineers, of their successful experience to date, in the design, construction, and use of, perhaps, nine-tenths of the railroad bridges with fixed spans of less than 300 ft. in length in service on American railways, it seems highly significant that the Committee has found so few changes necessary.

Although there will necessarily be variations in experience, and frank differences of opinion have been expressed, the 1920 A. R. E. A. Specifications have voiced the consensus of the opinions of the bridge engineers of American railways. It is not to be assumed, however, that this is the final word, as knowledge of the exact behavior of a number of details is still being sought.

For instance, the American Railway Engineering Association is arranging to investigate, by tests, the action of bridge-pins and of multiple I-beam girders, and intends to continue co-operation with the Society in the column tests. Unless some other agency begins first, the Association may conduct, as opportunity offers, a thorough investigation of plate girders, including compression flanges, stiffeners, rivets, effect of concrete encasement, etc. However, the Association has no desire to monopolize the field of investigation of bridge details and would welcome any well qualified research enterprises, just as cordially as it does all constructive criticisms of its 1920 General Specifications for Steel Railway Bridges and its 1922 Specifications for Movable Railway Bridges.

In the two specifications just mentioned, the bridge engineers of the railroads, by their joint labors, have made a sincere effort to meet their own needs, and although of open mind regarding the merits of a few alternate clauses, the writer believes the feeling is that 1920 A. R. E. A. Specifications, revised from time to time as may be found necessary, will be a reliable guide for both the designer and manufacturer.

C. G. EMIL LARSSON,‡ M. AM. SOC. C. E. (by letter).§—The writer finds that the Tentative Specification for Steel Railway Bridges is practically a copy of the Specification for Steel Railway Bridges issued by the American Railway Engineering Association. He fails to see how it can be of any benefit to the Profession to have the Society copy the A. R. E. A. Specification, or how it can increase the prestige of the Society. The A. R. E. A. Specification is suitable for some of the trunk lines of the United States, which roads always employ expert bridge engineers. Roads having no expert bridge engineer are likely to be misled by the proposed specification. It is not suf-

* Bridge Engr., Long Island R. R., Jamaica, N. Y.

† Received by the Secretary, March 1st, 1922.

‡ Asst. Chf. Engr., American Bridge Co., New York City.

§ Received by the Secretary, March 2d, 1922.

ficient to state in Article 104 that "for special cases the live load may be varied as required by the Engineer". There are various other Articles in the specification that should be modified to meet the special requirements.

The writer had hoped the Committee would draft a general specification that would be of service to the Profession as a whole. Such a specification, in his opinion, should emphasize the desired results, but not the methods to obtain them. A specification based on this principle would help to develop the art of bridge building.

O. H. Ammann,* M. Am. Soc. C. E. (by letter).†—The Tentative Specifications for Steel Railway Bridges evidently cover only the broad field of ordinary bridges. It is fortunate that they follow so closely in all essentials, the specifications of the American Railway Engineering Association, otherwise, they might cause confusion and lead to results opposite of what is expected, that is, uniformity in quality and serviceability. It is to be hoped that, eventually, common specifications for these ordinary structures may be agreed on by co-operation of the two Societies.

The Tentative Specifications, like those of the American Railway Engineering Association, are not applicable to large bridges, or even to the smaller bridges of uncommon type, and the question naturally arises as to where large bridges begin, or where the applicability of the Tentative Specifications ends. There may be differences of opinion on this question, but there appears to be no good reason why specifications cannot be written that will cover the entire field of bridge design. There is much common ground in the design of ordinary and extraordinary bridges, and the field of large bridges is practically virgin insofar as common understanding in the fundamentals of design is concerned.

That the American Railway Engineering Association set up detailed specifications for ordinary railway bridges, with minute rules of design, as a guide for the engineering forces of the various railroads, is readily comprehensible. The task of the Society, the writer believes, would be somewhat different. In his opinion, the work of the Committee could be made much more valuable, if it were to conduct research work and set up specifications, based thereon, applicable to the entire field of bridge design, particularly to structures not covered by ordinary specifications.

Naturally, such specifications could not cover details to the same extent as the Tentative Specifications, but that is not necessary. They should cover the fundamental principles of sound design, load, and stress assumptions, quality of material and workmanship, as applicable to all kinds of bridges, thus allowing a wide margin for the ingenuity and judgment of the designer in the working out of the style, general arrangement, and type of details. The Tentative Specifications contain many features which should be left to the judgment of the designer, such as type of truss, number of trusses, arrangement of certain details, etc., features which are largely determined by conditions other than excellence of design.

* Cons. Engr., New York City.

† Received by the Secretary, March 2d, 1922.

The true purpose of specifications is uniformity in strength. If too narrow and restrictive as to style and type of design, they tend to shackle originality and progressiveness, promote conventionality, and lack the necessary elasticity to adapt themselves to the ever-changing conditions. The Tentative Specifications are limited, for instance, to the use of a single grade of ordinary structural steel, and ignore the fact that, in recent years, a number of higher steels have found a proper place in bridges of even moderate size.

Some of the more important features of the Tentative Specifications on which there appears to be considerable diversion of opinion are the live load, impact formula, and unit stresses, more particularly the compression formula.

104.—Live Load.—The Committee has properly retained Cooper's engine loading. The writer, on a former occasion,* has expressed the opinion that there is not sufficient ground for abandoning that loading. It has become a standard by which railroad bridges can be easily gauged as to carrying capacity, and should not be lightly abandoned, unless another engine loading is produced that is more truly representative of the great variety of present and future locomotives. Thus far, no such loading has been produced.

Compared with any equivalent uniform load, which, after all, must be based on actual weights, any engine loading possesses the not insignificant advantage of conveying to the mind a truer picture of the actual load.

In Cooper's loading, both the engine concentrations and the uniform train load behind the engines, can be adapted, by simple proportion, not necessarily the same for both, to the actual increase in weight of these train units, and the loading has thus sufficient flexibility for all practical purposes.

106.—Impact.—The impact formula proposed by the Committee, which agrees with the new American Railway Engineering Association formula, is an improvement over the old formula of the Association, because it results in a justified economy of metal for spans longer than about 100 ft.; but it is less simple and retains the defect of the old formula of giving impact values that are too low for single-load concentrations and short lengths of load, up to about 25 ft.

Mr. Seaman's formula† and the simpler one proposed by Maj. Mount are better in this respect and, for all greater span lengths, give sections (the only proper criterion for comparison) which differ by not more than 5% from those obtained by the proposed formula.

On account of its simplicity, the writer considers Maj. Mount's formula, $\left(\frac{120}{90 + L}\right)$, or a slight modification thereof, much to be preferred to any of the other purely empirical formulas.

All the previously mentioned formulas, if used in connection with a basic unit stress of 16 000 lb. per sq. in., result in a waste of metal in long spans of, say, more than 500 ft. This is not due so much to the impact formula as to the low unit stress, but if a higher unit stress were allowed, the formulas

* *Transactions,* Am. Soc. C. E., Vol. LXXXIII (1919–20), p. 2000.

† *Proceedings,* Am. Soc. C. E., December, 1921, p. 711.

would give too low values for short spans; in other words, the impact formulas and the unit stresses are not properly correlated for all span lengths.

The simple empirical formula, $\frac{200}{100 + L}$, in combination with a unit stress of 20 000 lb. per sq. in., would give good results for all span lengths.

Whichever of the aforementioned formulas may be adopted, the writer would recommend that the length, L, should be taken to mean the aggregate loaded length on all tracks. This will result in a justified economy in bridges with more than one track. Although no comparative test results are available, it is only reasonable to expect that the impact percentage decreases with increasing number of tracks.

Further, on account of the "cushioning" effect of the ballast, it is reasonable to expect, and the English tests, barring erratic results, prove, that the impact in ballasted bridges is considerably less than in open-floor bridges. The writer, therefore, would recommend, pending further investigation, that ballasted bridges be proportioned for only a fraction, say, 75% of the impact allowance in open-floor bridges.

The semi-empirical formula,* of Gustav Lindenthal, M. Am. Soc. C. E.,

$$i = \frac{l}{l + d} \; \frac{1\,200 + \frac{a}{n}}{600 + 4a},$$

whatever justification its derivation may have, is the only one which takes all the factors mentioned automatically into consideration. In combination with the high basic unit stress of 20 000 lb. per sq. in., it gives reasonable results in all cases.

For single-track bridges with open-tie floor and spans up to about 500 ft., it results in steel weights that agree fairly close with those of the other formulas. In longer spans, in bridges with ballasted floors and in bridges with more than one track, it effects a justified saving.

Section 2.—Unit Stresses and Column Formula.—The writer does not favor the use of low unit stresses. He would rather make liberal assumptions for the external forces and possible combinations of such forces, and let the maximum stresses under extreme conditions reach high values (close to the elastic limit in tension members and to two-thirds of the buckling strength of compression members), provided that design and details are excellent in every respect.

It may be apprehended that the indiscriminate use of the proposed low unit stresses for compression, in particular, will result in unnecessary waste of metal. There appears to be no justification for such low unit stresses for properly designed compression members of small values of $\frac{l}{r}$. These low stresses will encourage poor design under cover of a safe margin, rather than result in greater safety.

In the writer's opinion, the old American Railway Engineering Association formula, $16\,000 - 70\,\frac{l}{r}$, in connection with the unit of 16 000 lb. per sq. in.

* *Engineering News*, August 1st, 1912.

for tension, gives a safe stress for properly designed columns. The specifications should prevent poor design by prescribing suitable reductions in the permissible stress in cases where thin unstiffened webs, flimsy latticing, such as flat lattice-bars, wide unsupported flanges, or composite parts of the section without direct lateral support, are used. Such reductions have not been sufficiently provided for in the Tentative Specifications.

The Rankine formula favored by Mr. Seaman is unnecessarily complicated. Its apparent scientific form is not justified, because the law of proportionality, on which its derivation is based, does not apply to the process of buckling of short columns, since the fiber stresses exceed that limit long before actual buckling takes place.

For long columns, with $\frac{l}{r}$ greater than the practical limits, Euler's formula is the only correct theoretical formula. It would be applicable also to shorter columns if the modulus of elasticity was introduced as a variable value for stresses greater than the limit of proportionality. In that form, it proves the fact that the buckling strength of a very short column $\left(\frac{l}{r} = 0\right)$ is identical with the yield point, that is, the stress for which the modulus of elasticity in steel becomes zero.

For intermediate values of $\frac{l}{r}$, which comprise the entire range of practical values, a purely empirical formula and, as the simplest form of such, the straight line formula appears to be as good as any other.

These remarks are made in the spirit of constructive criticism and with a full appreciation of the valuable work done by the Committee in the interest of the Profession.

J. B. Hunley,* Esq. (by letter).†—The Tentative Specifications are, in general, very similar to those of the American Railway Engineering Association, now in effect, but, being tentative, certain features merit discussion, not only to assure the adoption of a logical specification by the Society, but for the effect it may have on the revision of existing specifications.

Materials and workmanship have been highly developed and little difference of opinion can exist as to these requirements; but there are various ideas as to the type of live load and impact formulas which should be used, and the allowable intensity of working stresses, particularly for columns or struts, and it is to be hoped that these subjects will receive such study and consideration as will result in reaching sound conclusions.

Live Load.—It is admitted that the Cooper loading does not closely conform with any type of engine actually in use, but nothing better has been devised and its use has become so general, not only for the design of new railroad bridges, but particularly for the rating of existing bridges and engines, that it is doubtful whether it should be abandoned. It seems to be quite as representative of the modern heavy engine as it ever was of the

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† Received by the Secretary, March 3d, 1922.

older and lighter engine, and it is now so firmly established that the time for changing it has probably passed, unless there is in the future some radical change in engine or car design.

Impact Formula.—It is possible that a formula should be used providing more than 100% impact for short spans. Some recent experiments indicate that such high impact stresses exist, but, unfortunately, few tests have been made with American equipment. It is quite probable that, even under average conditions of track and equipment, the impact stress on short spans exceeds the live load, and tests in sufficient number should be made in order to arrive at some correct formula.

It has been contended that the special loading for short spans, consisting of two or more heavy concentrations, safely provides for impact stresses in excess of 100%, but this may be questioned. It is a well known fact that individual axle loads of locomotives may, and frequently do, exceed the average or assumed axle load by as much as 40 or 50%, with improperly adjusted spring hangers, and the specified concentrated loads can do little more than provide for this contingency.

Column Formula.—Each of the three formulas proposed has many supporters, probably because no one formula has been devised which is theoretically correct for any ratio of l and r in the ideal column, and which can be modified so as to give reasonably accurate results for the actual column, and yet is of such form that its use is not too laborious.

The straight line formula has little to recommend it, except its simplicity and the fact that it does fit, with some accuracy, the results of tests. The second term means little, mathematically, but is merely an approximation of the decrease in strength resulting from an increase in length. It is theoretically incorrect, as its values form a straight line, whereas the actual values must approximate a reverse curve. The values representing the strength of a steel column would not continue horizontally along the line, representing the yield point of the material, to an intersection with the Euler curve, but would drop off between points representing the actual and apparent yield points before it intersected the Euler curve, even if no bending was introduced before the critical load was reached. This results in a reversed curve which, for the actual column, is accentuated by its inherent defects, eccentricities, etc.

Other formulas, more rational, giving accurate results and but little more difficult of application, are available. The mere computation of the permissible working stress in a column is a small part of the careful design or thorough investigation of such members, and if the straight line formula has no particular merit other than ease of application, it is time to discard it.

The parabolic formula, $p = 12\,500 - 0.25 \left(\frac{l}{r}\right)^2$, has much in its favor and, although it is purely empirical, it fits closely the plotted results of tests and is about as easy to apply as the straight line formula for all ordinary values of $\frac{l}{r}$ less than 160 or 170, where, as often written, $13\,000 - 0.25 \left(\frac{l}{r}\right)^2$, it becomes practically tangent to the Euler curve. It would appear that 13 000 could

be used safely for the first term of this formula instead of 12 500 as proposed in the specification. When this value is used and the results are multiplied by 2.5, it will be seen that the curve falls well within or even below the averages of tests of pin-end columns.

The Rankine formula, $p = \dfrac{16\,000}{1 + \dfrac{l^2}{13\,500\,r^2}}$, if multiplied by the factor 2.5, representing a yield point of 40 000 lb., becomes tangent to the Euler curve, $\dfrac{16\,E}{\left(\dfrac{l}{r}\right)^2}$, when the ratio of l to r is about 300. It gives too high values of p, for values of $\dfrac{l}{r}$ from 0 to 75, and too low values between 90 and 250. This has been the principal objection to this formula. The factor in the second term of the denominator cannot be adjusted to make the curve fit the tests for all values of $\dfrac{l}{r}$. The curve, as shown by Mr. Seaman in his discussion* of this formula, is made to fit the average results of tests on flat end columns, by multiplying the formula by the factor of 2.25. This does not make the curve tangent to the Euler curve and assumes the yield point of the material as 36 000 lb., when it is probably nearer 40 000 lb.

Inasmuch as three formulas have been proposed, apparently without agreement, the suggestion of another one may not be welcomed, but it seems to the writer that the secant formula is well worth consideration. It is theoretically correct for all lengths of the ideal column centrally or eccentrically loaded, and by the assumption of one factor will properly provide for any inherent eccentricities and defects of the column. With very small values of $\dfrac{l}{r}$, the working stress approaches the allowable fiber stress and, with increasing values of $\dfrac{l}{r}$, the formula approaches the Euler formula, which is known to be correct for long slender columns.

Its curve closely follows that of the parabolic formula, for columns centrally loaded, but contains a factor for eccentrically loaded columns; and, for such columns, the term, c, representing one-half the width, takes into account, to some extent, the shape of the section.

The formula as usually written is:

$$p = \frac{f}{1 + \dfrac{e\,c}{r^2} \times \sec. \dfrac{l}{2}\sqrt{\dfrac{P}{E\,I}}} \qquad (1)$$

which may be written:

$$p = \frac{f}{1 + \dfrac{e\,c}{r^2} \times \sec. \dfrac{l}{2\,r}\sqrt{\dfrac{P}{E}}} \qquad (2)$$

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 715.

in which,

P = load on column;

A = area of column section;

$p = \frac{P}{A}$, average stress;

f = working stress;

e = eccentricity of application of load;

c = distance from neutral axis to outer fiber.

An examination of Formula (2) indicates that when $\frac{l}{r} = 0, p = f$, where there is no eccentricity. As $\frac{l}{r}$ increases, $\frac{l}{2r}\sqrt{\frac{P}{E}}$ approaches the value, $\frac{\pi}{2}$, and the formula becomes the Euler curve, when there is no eccentricity. It also indicates that p does not increase in the same proportion as f.

In using the ordinary column formula for an eccentrically loaded column, the average stress is, $p = \frac{f}{1 + \frac{e\,c}{r^2}}$, whereas, in Formula (2), the term, $\frac{e\,c}{r^2}$, is multiplied by sec. $\frac{l}{2r}\sqrt{\frac{P}{E}}$.

This formula is not widely used and has apparently not received the consideration it deserves, perhaps for the reason that it is more difficult to apply than many other formulas. By expanding the secant term and using only the first two terms of the series, the formula may be simplified, and becomes:

$$p = \frac{b}{2} \pm \sqrt{\left(\frac{b}{2}\right)^2 - C} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

in which,

$$b = \frac{8\,E}{K^2}(1 + a) + f$$

$$C = \frac{8\,E}{K^2} \times f$$

$$K = \frac{l}{r}$$

a = some value, including $\frac{e\,c}{r^2}$, where known eccentricity occurs, and a factor to provide for unknown eccentricity and defects, and for the condition at end of column, whether pivoted, hinged, or fixed.

It may be said that the formula is now only an empirical one, with a value, *a*, selected to form the desired curve. Although it is not so easily recognized, it still contains the bending factor. When the third term of the expansion series is included, slightly different values of p are obtained, but the equation becomes more complicated and its inclusion is scarcely justified for any prac-

tical purpose; but with tabulated values of $\frac{8\,E}{K^2}$, $\frac{8\,E}{K^2} \times f$, etc., the formula in this suggested form is not forbidding enough to condemn it.

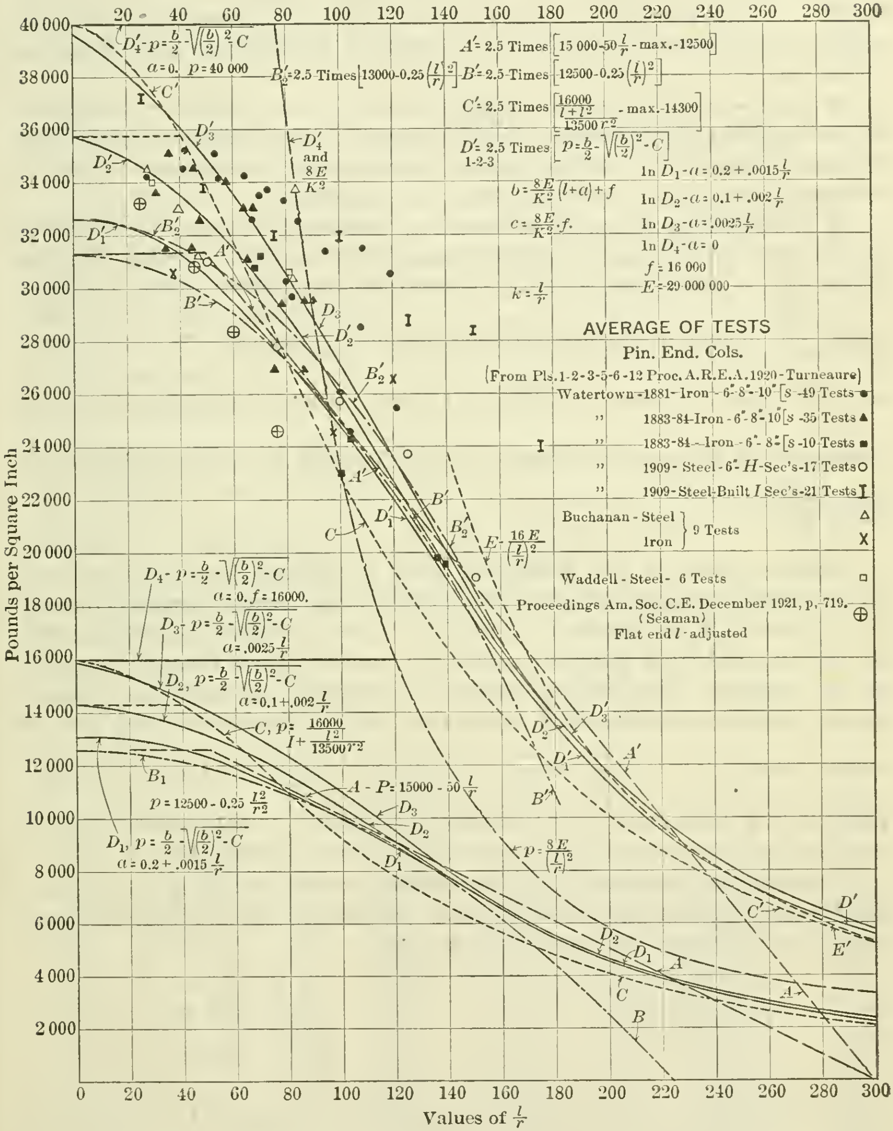

Fig. 18.

The values of p (with $E = 29\,000\,000$ and $f = 16\,000$) and with values of $a = (0.2 + 0.0015\ K)$, $(0.1 + 0.002\ K)$, and $(0.0025\ K)$, have been plotted, Fig. 18 (Curves D_1, D_2, D_3), with the three other formulas proposed. Curve D_1 ($a = 0.2 + 0.0015\ K$), practically coincides with the parabolic formula

through a long range of values of K, and gives a maximum value of $p = 13\,000$, corresponding to the parabolic and straight line maximum values. Curve D_2 ($a = 0.1 + 0.002\ K$), gives a maximum value of about 14 000, corresponding to the maximum value allowed with the Rankine formula. Curve D_3 ($a = 0.0025\ K$), gives a maximum value of 16 000. When the values of p are multiplied by 2.5, the curves, D'_1, D'_2, D'_3, touch the Euler curve, when K equals 200 to 250.

It must be remembered that with an increase in the value of f from, say, 16 000 to 40 000, the values of p do not increase in the same proportion, with the same value of a. This is peculiar to the secant formula and is due to different functions of p in both sides of the equation.

It is interesting to note that when a is assumed to be zero, which would be the case for the ideal pivoted columns, and $f = 16\,000$ (Curve D_4), the values of $p = 16\,000$ until a value of $K = 120$ is reached, where the curve becomes $\frac{8\,E}{K^2}$, or, if $f = 40\,000$, the curve becomes $\frac{8\,E}{K^2}$ with $K = 76$. The Euler curve for pivoted columns is $\frac{10\,E}{K^2}$, and if the other terms of the expansion series were retained, the curve for larger values of K would more nearly approach or equal $\frac{10\,E}{K^2}$.

Average values of the Watertown tests on pin-end columns have been plotted, with 2.5 times the values of p given by the various formulas, including the curve, $B'_2 = (13\,000 - 0.25\ K^2)$. It will be noted that Curves D'_1, B'_1, and B'_2, fall along the lower averages; Curve D'_2 passes through the mean of the averages. The Rankine curve, C'_1, exhibits its well known defect, namely, cutting across the field, being high for low values of K and low for higher values of K. When known eccentricity occurs, the term, $\frac{e\,c}{r^2}$, is computed, and if this was, say, 0.25, the term, a (Curve D_1), would become ($0.45 + 0.0015\ K$), or, for Curve D_3, a would become ($0.25 + 0.0025\ K$).

The value of this formula for investigating an eccentrically loaded column can best be illustrated by a concrete case. Assume the usual upper chord section of the box type, open on one side, having,

$A = 66.8$ sq. in.	$c = 11.8$ in.
$I = 5\,895$	$e = 2.0$ in.
$r = 9.4$	$\frac{e\,c}{r^2} = 0.267$

The safe load, $P = p\,A$, for the column will be computed by the formula, $12\,500 - 25\left(\frac{l}{r}\right)^2$, and the modified secant formula, using $a = 0.2 + 0.0015\ K$ (Curve D_1), and for values of $K = 50$, 100, and 150. It will be noted from Fig. 18 that the two curves are almost identical for this range of K. The computed values of P are as given in Table 5.

TABLE 5.

Parabolic Formula.				Secant Formula.			
$K = \frac{l}{r}$	$p_1 = 12\,500 - 0.25\left(\frac{l}{r}\right)^2$	$p = \frac{p_1}{1 + 0.267}$	$P_1 = p\,A$	$1 + a$	p	$P_2 = p\,A$	$\frac{P_2}{P_1}$
50	11 875	9 370	625 900	1.542	9 960	665 300	106.3 %
100	10 000	7 890	527 100	1.617	8 190	547 100	103.8 %
150	6 875	5 430	362 700	1.792	5 740	383 400	104.4 %

It is possible that the Committee eliminated the secant formula after due consideration and that it was the intent to limit the discussion of column formulas to the three proposed in the Tentative Specifications. However, the secant formula, either in the original or in some modified form, is so rational and has so many good qualities that any discussion of column formulas would not be complete without including it, and the writer can recommend it as an interesting study that, in time, may lead to its more general use, which he believes it deserves.

Table 6 of values of $\frac{8\,E}{K^2}$, $\frac{8\,E}{K^2} \times f$, etc., is included for the convenience of any one desiring to use the formula in this modified form. The values are shown for values of K, varying by 10; for any intermediate ratio, the value can be obtained by interpolating, with accurate results.

TABLE 6.—Values of Terms in Modified Secant Formula

$E = 29\,000\,000$

$f = 16\,000$ lb.

$$p = \frac{b}{2} \pm \sqrt{\left(\frac{b}{2}\right)^2 - C}$$

$$b = \frac{8\,E}{K^2}\,(1 + a) + f$$

$$C = \frac{8\,E}{K^2} \times f$$

$\frac{l}{r} = K$	K^2	$\frac{4\,E}{K^2}$	$\frac{\text{Diff.}}{10}$	$a = 0.2 + 0.0015\,\frac{l}{r}$	$a = 0.1 + 0.002\,\frac{l}{r}$	$a = 0.0025\,\frac{l}{r}$	$C = \frac{8\,E}{K^2} \times f$	$\frac{\text{Diff.}}{10}$
10	100	1 160 000	87 000	0.215	0.120	0.025	37 120 000 000	2 784 000 000
20	400	290 000	16 111	0.230	0.140	0.050	9 280 000 000	515 555 000
30	900	128 889	5 639	0.245	0.160	0.075	4 124 448 000	180 445 000
40	1 600	72 500	2 610	0.260	0.180	0.100	2 320 000 000	83 520 000
50	2 500	46 400	1 418	0.275	0.200	0.125	1 484 800 000	45 370 000
60	3 600	32 222	855	0.290	0.220	0.150	1 031 104 000	27 357 000
70	4 900	23 673	555	0.305	0.240	0.175	757 536 000	17 754 000
80	6 400	18 125	380	0.320	0.260	0.200	580 000 000	12 173 000
90	8 100	14 321	272	0.335	0.280	0.225	458 272 000	8 707 000
100	10 000	11 600	201	0.350	0.300	0.250	371 200 000	6 442 000
110	12 100	9 587	153	0.365	0.320	0.275	306 784 000	4 899 000
120	14 400	8 056	119	0.380	0.340	0.300	257 792 000	3 814 000
130	16 900	6 864	95	0.395	0.360	0.325	219 648 000	3 027 000
140	19 600	5 918	76	0.410	0.380	0.350	189 376 000	2 442 000
150	22 500	5 155	62	0.425	0.400	0.375	164 960 000	1 997 000
160	25 600	4 531	52	0.440	0.420	0.400	144 992 000	1 654 000
170	28 900	4 014	43	0.455	0.440	0.425	128 448 000	1 389 000
180	32 400	3 580	37	0.470	0.460	0.450	114 560 000	1 171 000
190	36 100	3 213	31	0.485	0.480	0.475	102 816 000	1 002 000
200	40 000	2 900	25	0.500	0.500	0.500	92 800 000	805 000
220	48 400	2 397	19	0.530	0.540	0.550	76 704 000	613 000
240	57 600	2 014	15	0.560	0.580	0.600	64 448 000	477 000
260	67 600	1 716	12	0.590	0.620	0.650	54 912 000	378 000
280	78 400	1 480	10	0.620	0.660	0.700	47 360 000	306 000
300	90 000	1 289		0.650	0.700	0.750	41 248 000	

Note.—Differences are divided by 20 for $\frac{l}{r}$ from 200 to 300.

Otis E. Hovey,* M. Am. Soc. C. E. (by letter).†—The character of the Tentative Specifications for Steel Railway Bridges presented by the Special Committee disappoints the writer. He had hoped that the Committee would take advantage of its opportunity and prepare and present a general specification for bridges instead of following the old practice of attempting to prescribe minute details of construction. The specification presented seems to be more like a set of instructions for the use of bridge draftsmen than a true specification. For many years, the tendency has been for railroad engineers to specify more and more concerning relatively unimportant details. One noticeable result of this procedure is that the younger designing engineers gradually become satisfied to observe carefully the printed rules. They are not encouraged to think deeply of the problems entrusted to them. Initiative is not stimulated, and advances in design and methods of construction are not encouraged.

It is perfectly proper for the engineer of a railroad to describe in detail just the kind of bridges he may wish to use on his own road; but the writer feels that the Society should attempt to prepare a genuine general specification, laying down such requirements as are vital to good design, suitable materials, proper workmanship, and construction, or leave the field to those who wish to express their personal preferences for certain details through the medium of their specifications.

A thoughtful study of the regulations prescribed by law in France might assist one to approach the problem from a standpoint quite different from that of the Committee. These regulations are of a general character, and a brief paragraph in the second article of the Act of August 29th, 1891, states that "these formulas are given as a matter of information only and do not limit in any way the initiative of the engineers, who may employ any method which they may deem expedient", and this refers to as vital a matter as unit stresses.

In this is the nucleus of the whole matter. The Society should endeavor to stimulate and not hamper the development of the best principles of bridge design. The Society should encourage thought, originality, and initiative in its members; but, at the same time, it should be sure to place before them the broad general principles to be followed and epitomize the experience of the many thoughtful and competent engineers who have given their best efforts to the development of good practice in bridge design and construction.

The writer had intended to limit his discussion to the general principles previously mentioned, but has been requested to present the following method of designing the latticing of compression members. The method is not new, having been used for many years, but may be of value, as it is developed with special reference to the Rankine column formula in Article 201 of the Tentative Specifications.

The Rankine column formula which, in form, is easily derived from the Euler equation, may be stated as follows:

$$\frac{P}{A} = \frac{S}{1 + \dfrac{l^2}{c\,r^2}} \quad \text{.........................(1)}$$

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† Received by the Secretary, March 6th, 1922.

in which,

P = the total axial load on the column,
A = its area,
S = the permissible maximum fiber stress,
l = its length,
r = its radius of gyration, and
c = an experimental constant.

For a short column, $\frac{P}{A} = S$, so it is evident that the expression, $\frac{l^2}{c\,r^2}$, is introduced to provide for bending stresses in a column of material length.

By solving for S,

$$S = \frac{P}{A} + \frac{P}{A} \times \frac{l^2}{c\,r^2}$$

and the portion, $\frac{P}{A} \times \frac{l^2}{c\,r^2}$, is the allowance for bending expressed in unit stress, or one may write:

$$f = \frac{P}{A} \times \frac{l^2}{c\,r^2} \qquad (2)$$

A bent column with round ends will take the general form shown in Fig. 19. In order to arrive at a method of calculating lattice bars, it may be assumed as, at least, an approximation, that the forces acting to bend the column under axial load may be replaced by a horizontal unit load of w acting uniformly over the length of the column.

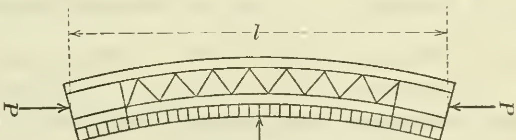

FIG. 19.

Referring to Fig. 20, the bending moment at the middle of the column will then be:

$$M = \frac{w\,l^2}{8}, \text{ but } R = \frac{w\,l}{2}, \text{ hence } M = \frac{R\,l}{4},$$

and we may write:

$$M = \frac{R\,l}{4} = \frac{f\,I}{y}$$

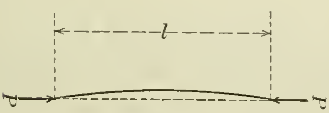

FIG. 20.

in which f is the extreme fiber stress due to bending, I is the moment of inertia of the column section, and y is the distance of the extreme fiber from the neutral axis. Replacing I by the equivalent value, $A\,r^2$,

$$\frac{R\,l}{4} = \frac{f\,A\,r^2}{y}, \text{ but } f = \frac{P}{A} \times \frac{l^2}{c\,r^2},$$

hence,

$$\frac{R\,l}{4} = \frac{P\,l^2}{c\,y},$$

and,

$$R = \frac{4\,P\,l}{c\,y} \qquad (3)$$

If Equation (1) takes the form,

$$\frac{P}{A} = \frac{S}{1 + \dfrac{l^2}{13\,500\,r^2}}$$

Equation (3) becomes

$$R = \frac{4\,P\,l}{13\,500\,y} \qquad (4)$$

R is the calculated shear in the end lattice-bars of the column. If the bars make an angle of θ with the axis of the column and the column is latticed on two sides, the stress in each lattice-bar becomes

$$S_1 = \frac{R \text{ co-sec. } \theta}{2} \text{ for single lacing;}$$

and,

$$S_2 = \frac{R \text{ co-sec. } \theta}{4} \text{ for double lattice.}$$

The compression formula of the American Railway Engineering Association Specifications of 1910 is $S = 16\,000 - 70\,\frac{l}{r}$. Proceeding in a similar manner, the allowance for flexure corresponding to the term, $70\,\frac{l}{r}$, reduced to shear at right angles to the column is found to be:

$$R = 280\,\frac{A\,r}{y} \qquad (5)$$

The values of S_1 and S_2 are in the same form as given for the Rankine formula.

The column formula given in the A. R. E. A. Specifications of 1920 is $S = 15\,000 - 50\,\frac{l}{r}$. From this is obtained:

$$R = 200\,\frac{A\,r}{y} \qquad (6)$$

It will be interesting to compare the values of R obtained from Equations (4), (5), and (6), to an actual column. For this purpose, assume a column made up of two channels, 15 in. by 40 lb. per ft. The value of r is 5.43 in. and $r^2 = 29.48$. Assume column lengths from 24 to 40 ft., varying by intervals of 2 ft.; calculate the capacity of the column for each length, and find values of R for each length. The results are given in Table 7.

TABLE 7.

$$S = \frac{16\,000}{1 + \dfrac{l^2}{13\,500\,r^2}};\ R = \frac{4\,P\,l}{13\,500\,y}$$

Length, in feet.	Length, in inches.	$\frac{l}{r}$	S= unit stress allowed.	Area, in square inches,	S= capacity of column, in pounds.	R= shear, in pounds.	Total stress in lattice-bars, in pounds at 45°	Percentage of column stress.
24	288	53.0	13 238	23.52	311 400	3 540	5 010	1.61
26	312	57.4	12 860	"	302 500	3 730	5 280	1.75
28	336	61.9	12 455	"	292 900	3 890	5 500	1.88
30	360	66.3	12 069	"	283 900	4 040	5 710	2.01
32	384	70.7	11 675	"	274 600	4 170	5 900	2.15
34	408	75.1	11 282	"	265 390	4 280	6 050	2.28
36	432	79.5	10 893	"	256 200	4 370	6 180	2.41
38	456	84.0	10 508	"	247 200	4 450	6 290	2.54
40	480	88.4	10 133	"	238 400	4 520	6 390	2.68

From the formula, $S = 16\,000 - 70\,\frac{l}{r}$, $R = 280\,\frac{A\,r}{y}$. Substituting the values from the column previously mentioned, R is found to be equal to 4 470 lb. and the lattice-bar stress at 45° is 6 740 lb., and this value is constant for all column lengths.

From the formula, $S = 15\,000 - 50\,\frac{l}{r}$, $R = 200\,\frac{A\,r}{y}$, hence $R = 3\,410$ lb. and the lattice-bar stress at 45° is 4 820 lb. This is also constant for all column lengths.

G. A. Haggander,* Esq. (by letter).†—These specifications are very similar to, and the most important features are identical with, the General Specifications for Steel Railway Bridges for fixed spans less than 300 ft. in length, adopted by the American Railway Engineering Association in 1920.

On account of the fact that the Tentative Specifications have no span limit, certain modifications are due. In other cases, minor changes are made in the wording. The writer considers the A. R. E. A. Specification to be a very good one, and one that will be used by railroad engineers in the design of steel railway bridges almost entirely, regardless of whether the Society adopts a similar specification. From the writer's point of view, it is a mistake at this time to publish two specifications so nearly alike. If the Committee feels that the A. R. E. A. Specification should be modified in some respects, the proper course would be to have that specification modified. It is acknowledged that it is not correct in every detail, and some changes will be requested by the Committee at the 1922 Convention. It seems, therefore, that the Society should either adopt the A. R. E. A. Specification for spans of less than 300 ft. in length, or suggest certain changes to the Association, and confine its work to spans of longer length, rather than attempt to cover the same field with a similar specification.

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† Received by the Secretary, March 4th, 1922.

H. Ibsen, Esq.* (by letter).†—The Tentative Specifications are so much like the Specifications of the American Railway Engineering Association that they practically amount to a revision of them and, for that reason, the writer hopes that, at some future date, the two Societies may be able to agree on a joint specification.

On the following articles, the writer disagrees with the Committee, and suggests certain changes.

12.—Spacing of Trusses.—Change the last five words: "one-twentieth of the span" to "one-fifteenth of the span", as there is apparently no ordinary span length for which such close spacing of trusses or girders would be used.

13.—Clearance.—Change the last sentence to read: "The required super-elevation of the outer rail shall be specified by the purchaser." The requirement for this varies considerably and the purchaser should always decide. It is best to word this Article so that this requirement will not be overlooked.

15.—Timber Floor.—Change the first sentence to read: "Ties shall be not less than 10 ft. long, spaced not more than 4 in. apart, and dapped ½ in. over the lowest part of the girder, but no tie shall be dapped more than 1¼ in."

The sentence relative to securing the girders or stringers against bunching "by wooden guard-rails, 6 by 8 in., notched 1 in., and fastened to each tie by ¾-in. bolts," should be changed to read: "by wooden-guard rails, 6 by 8 in., with wooden spacers 1½ by 4 in., spiked to same. The guard-rail shall be fastened to every tie with ¾-in. bolts."

Present rolling stock is so heavy that on open-floor bridges the maximum spacing of ties should not be more than 4 in. In case of derailment, ties will generally be bunched and broken with a 6-in. tie spacing, whereas with a 4-in. spacing, the writer cannot recall having seen anything worse than the tops cut and splintered on some of the ties. The maximum depth to which the ties are to be dapped, should be specified, otherwise the cut will be too deep on heavy girders where the flange plates would be several inches thick. Notching the guard-rails 1 in. over the ties is expensive and of little use, as the 1-in. slab generally splits off. It is cheaper and much better to use spacers spiked to the guard-rail.

16.—Ballasted Floors.—In the third line, of this Article, there should be added between the words, "rail", and "the weight", the following, "and the weight of same shall be taken as 120 lb. per cu. ft." This gives a safe average weight, and it is doubtful whether calculating the weight of materials would give much closer results, as one cannot tell just what material will be supplied for ballast.

102.—Loads.—The loads for which stresses are to be calculated are so important that they should be made to stand out more clearly by being printed separately in column form.

104.—Live Loads.—The proposed live load seems to be quite as representative of the general type of present equipment, as any loading that could be devised. It is convenient of form, familiar to both engineers and officials, tables and diagrams of all kinds, pertaining to its use, have been published,

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† Received by the Secretary, March 11th, 1922.

and until there is a decided change in the present type of locomotives, the proposed live load should be used.

105.—Multiple Tracks.—For a three-truss deck span with the outside trusses 52 ft. apart, the load on the center truss, using the percentages specified, would be: For four tracks loaded, 2.8 W; for three tracks loaded, 2.8 W; and for two tracks loaded, 2.7 W. With the outside truss 48 ft. apart, which is not an improbable condition, the load on the center truss for four tracks loaded, would be 2.57 W; for three tracks loaded, 2.63 W; and for two tracks loaded, 2.64 W.

This does not seem to be consistent and the reduction for four tracks loaded should not be more than 25 per cent. Although it is self-evident, the writer believes it would be best to make it clear that the reduction for the outside trusses is 10% and not 30%, in a three-truss four-track bridge.

106.—Impact.—It is probably true that the impact stresses on very short span bridges are somewhat higher than the proposed formula would give, and it would be desirable if tests could be made on short spans with the equipment used in the United States. Until that is done, there would seem to be no necessity for changing the proposed formula. No trouble has been had with the short spans designed for 100% impact.

As impact formulas are used in which the loaded length means the aggregate loaded length on all tracks on bridges carrying more than one track, it would be best to make the definition of L for web members clear on this point, as a mistake in this respect would further penalize trusses of multiple-track bridges.

201.—Unit Stresses.—Of the three column formulas proposed, the writer prefers the parabolic formula, but would make it read, $13\,000 - 0.25 \left(\frac{l}{r}\right)^2$.

The shear in plate-girder and I-beam webs is given as 10 000 lb. per sq. in. for net section. Should this not be gross section? It is preferable to specify the stress on the net section, but in that case, it should be 12 000 lb. instead of 10 000 lb.

Cast steel is not as reliable in tension as structural steel and the permissible tensile stress should be reduced 10% from that of structural steel.

The writer thinks turned bolts with driving fit are as good as field rivets and that the reduction for both should be the same, preferably 25 per cent.

The clauses which define the permissible bearing stress on masonry should be transposed so as to come after the clause defining the bearing on expansion rollers.

206.—Combined Stresses.—The third line of this Article reads, "so that the combined fiber stress will not exceed 16 000 lb. per sq. in." Is it the intention to allow the same combined fiber stress for compression as for tension?

In the writer's opinion, the combined fiber stresses should not exceed the unit stresses specified in Article 201.

313.—Long Rivets.—Specially designed rivets should be used when the grip exceeds five times the diameter of the rivets, at least for field rivets.

314.—Pitch of Rivets at Ends of Members.—Add in the third line, after "width", the words, "or depth".

316.—Outstanding Legs of Angles.—A width of ten times the thickness, for outstanding legs of stringer angles, is as much as should be allowed, where they are not reinforced by flange-plates.

324.—Splices.—The writer prefers full splicing of compression members as well as of tension members, as he believes that, even with the greatest care, there is not a full uniform bearing of all the joints after the bridge is erected.

329.—Pin-Plates.—The minimum length of pin-plates should be specified.

408.—Proportioning Solid Floors.—The writer has found that when the specification is worded like this one, there is always doubt about how it is to be defined. It should be clearly stated, whether or not the net section of both the top and the bottom flanges shall be used for designing both flanges. The writer's practice is to design the top flanges for the moment of inertia of the entire gross section and the bottom flange for the moment of inertia of the entire net section. This gives satisfactory results. The same remarks hold true for Article 602, "Design of Plate Girders."

606.—Thickness of Web-Plates.—It seems that $\frac{1}{20}\sqrt{D}$ gives a web that is not in proportion with the heavy girders required for the loading specified; the writer would increase this to $\frac{1}{16}\sqrt{D}$.

902.—Properties.—Is not the elongation of 22% in 2 in. out of place in this Article? It seems to belong in Article 916.

937.—Workmanship and Finish.—The specifying of only that, "the castings shall be free from injurious defects", leads to disputes with the shop, and the writer would propose to add after the last sentence, the following: "The finished casting shall show no blow-holes exceeding ½ sq. in. in area or 1 in. in length, and the aggregate length of blow-holes cut by a straight line, laid in any direction, shall not exceed 1 in. in 1 ft.

1002.—The word "may" in the last line of this Article should be changed to "shall".

1004.—Rivet Holes in Punched Work.—There will be considerable difficulty in punching five thicknesses of such heavy metal, and live up to the test for matching of holes prescribed in Article 1005; the writer's opinion is that ¾ in. should be the limit for full punching.

1014.—Field Rivets Furnished.—The provision for 15% plus 10 rivets excess over the nominal number, is rather large. The writer's experience is that 10% plus 10 rivets is plenty.

1018.—Screw Ends.—In the first line, change the words "ends" to read "nuts".

1019.—Welds.—In view of the preference given in these specifications to steel castings for important bearings, the writer believes it is a mistake to permit any welding to be done in such castings without safeguarding the work by the following additional statement: "Welding of defects in steel castings, even of a minor nature, will not be allowed except by special permission of the Engineer."

1020.—Bearing Surfaces.—"The top and the bottom surfaces of base and cap plates of columns and pedestals, except where they are in contact with masonry, shall be planed or hot-straightened." The writer can see no reason for not attempting to obtain as good a bearing for columns as is required for plate girders in the same Article.

1103.—Computed Weights.—In the second line of Paragraph (*c*) of this Article, after the word "drawings", add "deducting for caps, cuts, and open holes".

In Paragraph (*d*), the addition of 10% for fillets and over-run is too liberal, the writer thinks 5% is sufficient.

1105.—Marking and Shipping.—Relative to Paragraph (*a*), it is often necessary to ship bolts, rivets, etc., by baggage car during erection, and packages shipped in this manner should not weigh more than 200 lb.

1202.—Surfaces in Contact.—Linseed oil alone does not seem to be a proper coating for surfaces in contact. The old-fashioned way of using a heavy coat of paint on each surface is objectionable, because it makes it difficult to get tight rivets on heavy work, but there should be some pigment mixed with the linseed oil, just enough so that the paint will not streak and run on a vertical surface. A red lead paint mixed in the following proportions would be satisfactory: 100 lb. of red lead paste, mixed 7 lb. of linseed oil to 100 lb. of dry red lead; 0.2 lb. of lamp black; and 3.5 gal. of boiled linseed oil.

1206.—Machine-Finished Surfaces.—Abutting joints and base-plates should have some covering, even if it means a little trouble in cleaning them, as they may have to lie around a long time. The writer believes in covering them with heavy lubricating oil and wrapping them with burlap.

C. E. Sloan,* Assoc. M. Am. Soc. C. E. (by letter).†—The contemplated issuance by the Society of a steel railway bridge specification at this time appears to be of doubtful expendiency, as the proposed specification is similar in all essentials to that drafted some years ago by the American Railway Engineering Association.

The latter specification, since its first publication, has been subjected to thorough discussion and investigation, and it has been revised in order to make it up to date in all respects with present-day knowledge and experience.

It would seem that the interests of economy and progress in the fabrication of steel structures can best be served by the adoption of a single standard specification. Such a specification will tend to uniform quality of both material and workmanship and will further eliminate doubt as to the requirements of the purchaser.

The A. R. E. A. specification has become well known and has gone far toward the standardization of American shop practice in regard to railway bridges. In view of the similarity of names of the originating bodies, the entrance into this field of a competing specification would result in confusion and uncertainty. This same confusion would also apply to the drafting rooms of the bridge companies, with consequent errors and delays in the preparation and approval of plans.

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† Received by the Secretary March 23d, 1922.

It appears to the writer, therefore, that the efforts of the Society will be of greatest benefit if its influence is exerted toward securing a wider adoption of the A. R. E. A. specification, which has been evolved by a body that will have the closest interest in the use and application of the specification to its own special field of engineering.

For these reasons it appears that the Society should refrain from issuing steel railway bridge specifications until the need for them becomes more apparent.

ALBERT REICHMANN,* M. AM. SOC. C. E. (by letter).†—It would seem desirable to have a common specification issued by the American Railway Engineering Association and the Society. The writer would regret to have a new set of specifications added to the large variety already in use.

The Tentative Specifications are intended for railroad work of unlimited span lengths, whereas the specifications of the A. R. E. A. are for spans up to 300 ft. in length. The writer much prefers the latter method and believes it is wiser to issue special specifications for the spans of long lengths. Many special features and special materials are involved in structures of long spans, which cannot be covered in a general specification.

Article 6.—The writer does not favor the requirement that material ordered prior to the approval of the shop drawings shall be at the risk of the Contractor. The time of delivery generally will be too short to permit ordering material after the approval of the shop drawings. Probably it would be best to omit any reference to the ordering of material and let each contract be decided according to the conditions prevailing as regards delivery, completeness of design drawings, necessity for layouts prior to ordering material, etc.

Article 10.—This Article would be modified if the limit of span length for these specifications was 300 ft.

Article 12.—If the limit for span length was 300 ft., the width, center to center of trusses, should be not less than one-fifteenth of the span length.

Article 18.—Change to "Square spans with floor system and skew spans with ballasted floor shall preferably have end floor-beams."

Article 102.—After "longitudinal forces", add, "and the combination of these stresses used in proportioning the member. In plate girders the maximum shear and maximum moment shall be given at intermediate points where necessary for detailing."

Article 104.—Add to this Article: "A minimum live load consisting of a train weighing 1 200 lb. per lin. ft. on one track, shall be used in combination with lateral forces". (Article 109.)

Article 105.—After "impact", add, "and centrifugal stresses if any."

Article 106.—There is often a question of the value assumed for L in the impact formula. In the value for L, the floor system is not mentioned. The writer would suggest that this Article be made clearer by writing: "$L =$ span length for chords, end posts and flanges of girders and loaded length for partial loading counting from first driver to end of span. For floor-beams, the sum of the panel lengths on each side shall be taken as the loaded length."

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† Received by the Secretary, April 3d, 1922.

Article 107.—This Article should read: "For bridges designed exclusively for electric power service, etc." A clause should be added, specifying the impact allowance for bridges having ballast floor. It is suggested that 75% of the regular allowance be used. The last sentence in this Article should read: "Impact shall not be added to stresses produced by longitudinal, lateral, or centrifugal forces."

Article 108.—The percentages as given in this Article cannot under any condition of overloading produce sections exceeding those produced by the regular loading. The desired result can be obtained by changing the last figure to 40 per cent.

Articles 109, 110, and 111.—These Articles, as written, permit of more than one interpretation. The lateral forces should be considered as of two kinds, namely, first, actual wind force, tending to overturn the structure; and, second, such effects as horizontal impact and vibrations, which cannot be considered as affecting the structure as a whole, but only the bracing. With this idea in mind, it is suggested that these articles be re-written, as follows. The minimum live load mentioned in Article 111 is now included in Article 104, among the other live loads specified:

"*Article 109a.*—A wind force of 30 lb. per sq. ft. on 1½ times the vertical projection of the structure on a plane parallel to its axis, shall be assumed on all spans and viaduct towers, when subject to live load, and the resulting effect on all parts of the structure ascertained. On all spans, this wind force shall be taken as not less than 200 lb. per lin. ft. on the loaded chord and 150 lb. per lin. ft. on the unloaded chord.

"*Article 109b.*—A wind force on the train, taken as a moving load, of 300 lb. per lin. ft. on one track, applied 8 ft. above the base of rail, shall be assumed for all spans and viaduct towers and the resulting effect on all parts of the structure ascertained.

"*Article 109c.*—A wind force of 50 lb. per sq. ft. on 1½ times the vertical projection of the structure on a plane parallel to its axis, shall be assumed on all spans and viaduct towers, when not subject to live load, and the resulting effect on all parts of the structure ascertained, including anchorage.

"*Article 110a.*—A lateral force of 10% of the specified live load on one track, acting as a moving impact load, but not exceeding 900 lb. per lin. ft., shall be assumed as affecting the bracing only of the loaded chord in all spans; but this lateral force shall not be considered as being passed on into bracing of viaduct towers.

"*Article 110b.*—The lateral bracing between compression members of all spans and between the legs of viaduct towers shall have dimensions not less than those determined by a lateral force, which shall be considered as producing a transverse shear equal to 2½% of the total axial stress in the braced members in any panel.

"*Article 111.*—In determining the effect of the lateral forces on the main members of all spans and viaduct towers, Articles 109*a* and 109*b* should be combined, or Article 109*c* should be used alone. In determining the effect on the bracing, Articles 109*a* and 110*a* should be combined, or Article 109*c* or 110*b* should be used alone."

Article 113.—As it seldom, if ever, happens that the brakes are applied with such a force that all the wheels in the train slide on the rails, whereas the drivers frequently slide on the rails in starting the train, it seems reasonable to provide for a longitudinal force only of 20% of the load on the drivers; and in order to take advantage of the fact that the continuity of

the track helps to spread the effect over some distance, the following wording of this Article is proposed: "Provision shall be made in the design for the effect of a longitudinal force of 20% of the load on the drivers on one track only, applied 6 ft. above the top of the rail. The traction effect shall be considered spread uniformly over a distance of 300 ft."

Article 114.—The writer cannot conceive of any case, in an ordinary bridge, such as these specifications are intended to cover, in which temperature stresses need be taken into account. In regard to such stresses in the bracing of viaduct towers, Article 802 covers that case. It is proposed that Article 114 be omitted.

Article 201.—As now stated, the requirement of 16 000 lb. unit stress net section, in extreme fiber of girders conflicts with Article 602. The following wording of this line is proposed: "Tension on extreme fiber of rolled shapes, built sections, and girders proportioned by their moments of inertia, net section (see Article 602), 16 000 lb. per sq. in."

The line referring to shear in webs as 10 000 lb. per sq. in. net section, should read: "Average shear in plate-girder and I-beam webs, gross section, 10 000 lb. per sq. in."

As the shear along the depth of the web varies considerably from about 12 000 lb. and more at the center to zero at the edges, the average should be specified. It seems inconsistent to specify shear on net section, inasmuch as it is impossible to have a web fail in pure shear without ripping the plate along the whole depth on the outside of the rivets.

Shear and bearing value are reduced 15% for field rivets. This is very objectionable as it changes the number of rivets for field connections in trusses. It adds considerable work, inasmuch as the shop-riveted connections are often changed to field-riveted connections and *vice versa.* The writer likes the A. R. E. A. specification better, in which the values for shear and bearing are reduced 25% for countersunk rivets, hand-driven rivets, field rivets in floor connections, and turned bolts.

Article 202.—The requirement in this Article makes it unnecessary to specify any limit to the horizontal shear at the root of the angles, which has been set in the A. R. E. A. specifications of 1920 at 4 000 lb. per sq. in. Furthermore, the following articles will prevent the use of a section, which will not satisfy theory as well as good practice, namely, Articles 304, 316, 603, 604, and 606. Article 603 will especially prevent the use of side-plates, except in the most extreme cases. As the maximum shear and maximum moment cannot occur in ordinary bridgework, except in floor-beams or cross-girders supporting two lines of stringers or other construction of similar nature, it would seem advisable to point this out in the Article, in order to avoid useless speculation on this disputed point. In stringers and deck and through girders, it would take an unusual type of girder and one in which the web is heavier than the flange angles in order to obtain a shear of 4 000 lb. at the root of the angles, and for ordinary cases, in which the angles are of the same thickness as the web, or thicker, it is not possible to get a shear at the root of the angles greater than 2 500 lb., assuming, in both cases, that the web

is calculated for an average unit shear of 10 000 lb. An examination of the formula for shear shows that to be so. If the formula for unit shear,

$$U = \frac{V M_s}{t I}$$

is modified, for convenience of analysis and by allowable approximations to,

$$U = \frac{V}{t h} \times \frac{A_1}{A}$$

in which A_1 is the area of the flange above or outside the point at which the unit shear is U, and A is the total flange area, the following result would be obtained. At the end of the girder, where V is a maximum, $\frac{A_1}{A}$ is about one-half and assuming each flange angle to have the same thickness as the web, we would have $t = 2w$, in which w is the thickness of the web. On the assumption of an allowable average unit shear of 10 000 lb., we have,

$$\frac{V}{w h} = 10\,000 \text{ lb.}$$

and, therefore,

$$U = \frac{10\,000\, w\, h}{2\, w\, h} \times \frac{1}{2} = 2\,500 \text{ lb.}$$

At or near the center of the girder, the external shear is about 0.3 of the maximum, and $\frac{A_1}{A}$ is close to 0.9, hence,

$$U = \frac{0.3 \times 10\,000}{2} \times \frac{9}{10} = 1\,350 \text{ lb.}$$

For the case where the maximum shear and maximum moment occur at the same section the unit shear may be greater than 2 500 lb. at the root of the angles, but invariably the maximum diagonal tension in the web will be reached before the unit shear in the angles exceeds 4 000 lb. If one takes a girder in which the shear would call for a web of 40 by 1½ in., whereas the moment would only call for a flange of two angles, 6 by 6 by ⅝ in., one obtains a diagonal tension in the web of 16 050 lb. against a shear in the angles of 4 000 lb. It is proposed that Article 202 be worded, as follows: "The diagonal tension in webs of floor-beams and cross-girders or similar construction at points where maximum shear and maximum bending occur simultaneously, shall not exceed 16 000 lb. per sq. in."

Article 208.—As it is not possible to design any truss, whether pin-connected or riveted, without introducing secondary stresses, the writer would propose to word the first sentence of this Article, as follows: "Designing and detailing of trusses shall be made with a view of avoiding secondary stresses as much as possible."

Article 209.—Flanges of plate girders should have the same gross section area. If determining the tension flange in accordance with Article 201 and others, and the compression flange according to Article 209, would yield dif-

ferent gross sections of the two flanges, they should be made like the greater one. It is recommended, therefore, that the words "shall not be less than" be changed to "shall be equal to", and that the reference to I-beams be omitted.

Article 306.—Change to read: "The effective area of single angles (with or without lug angles) in tension shall be assumed as the net area of the connected leg plus 50% of the area of the unconnected leg. The effective area of two or more angles in tension, riveted together, is the net section of the sum of the angles."

Article 308.—According to this Article, "Connections shall have a strength at least equal to that of the members connected." This provision is generally hard to interpret and follow and leads to argument and changes on approval. This is a good opportunity to specify when lug angles shall be used. Change this Article to read: "Connections shall have a strength equal at least to the stress in the members connected and shall be made, as nearly as practicable, symmetrical with the axis of the member. Connections for laterals shall contain at least three rivets and for single-angle laterals, lug angles shall not be used for connections requiring six or less rivets."

Article 310.—Change this Article to read:

"The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance preferably shall be not less than $4\frac{1}{2}$ in. for $1\frac{1}{4}$-in. rivets, 4 in. for $1\frac{1}{8}$-in. rivets, $3\frac{1}{2}$ in. for 1-in. rivets, 3 in. for $\frac{7}{8}$-in. rivets and $2\frac{1}{2}$ in. for $\frac{3}{4}$-in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be as follows:

"Diameter of rivets....	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.	1 in.	$\frac{7}{8}$ in.	$\frac{3}{4}$ in.
"Compression members.	9 in.	8 in.	7 in.	6 in.	6 in.
"Tension members.....	12 in.	10 in.	9 in.	8 in.	8 in.

"For angles with two gauge lines and rivets staggered, the maximum pitch in each line shall be twice the above. If two or more web-plates are used in contact, stitch rivets shall be provided to make them act in unison. Between the flanges, stitch rivets shall be spaced not more than twenty-four times the thinnest plate in a longitudinal or transverse direction."

Article 311.—The exact edge distance from the center of any rivet to a sheared edge should be given, instead of a rule for calculating each one. The $1\frac{1}{2}$-in. edge distance to a sheared edge for a $\frac{7}{8}$-in. rivet is generally used. By the Society rule, $1\frac{3}{4}$ times $\frac{7}{8}$ in. would make the edge distance $1\frac{17}{32}$ in. and, in consequence, many details would be changed because of this difference. The following minimum edge distances from the center of any rivet to a sheared edge are recommended:

Diameter of rivet......	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.	1 in.	$\frac{7}{8}$ in.	$\frac{3}{4}$ in.
Sheared edges..........	$2\frac{1}{4}$ in.	2 in.	$1\frac{3}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{4}$ in.
Rolled edges...........	2 in.	$1\frac{3}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.

Article 312.—Add to this Article: "$1\frac{1}{4}$-in. rivets in 5-in. legs and $1\frac{1}{8}$-in. rivets in 4-in. legs."

Article 313.—Change to read: "The grip of rivets carrying calculated stress shall generally not exceed 11 in. for $1\frac{1}{4}$-in. rivets, 8 in. for $1\frac{1}{8}$-in. rivets, 6 in. for 1-in. rivets, $4\frac{1}{2}$ in. for $\frac{7}{8}$-in. rivets and $3\frac{3}{4}$ in. for $\frac{3}{4}$-in. rivets." The rule given in the specification is too tedious to apply.

Article 319.—It is advisable to state this Article more plainly and the following is proposed:

"The lacing of compression members shall be proportioned to resist a transverse shearing stress of $2\frac{1}{2}\%$ of the direct stress. One-half of this shearing stress shall be resisted by the lacing on each side (cover-plates considered as lacing). The stress in the individual lacing-bar shall be taken as the component of the shear in the direction of the bar, in case single lacing is used and half the amount if double lacing is used. The thickness of the bar shall be determined by the compression formula in Article 201, in which l shall be taken as the distance between connections to the main sections, and the value of $\frac{l}{r}$ of the bar shall not exceed 140 for single lacing and for double lacing not riveted at the intersections and 170 for double lacing riveted at the intersections. Double lacing intended to carry tension only may be used in combination with lacing struts of angle or channel shape in each panel of lacing. The minimum width of lacing bars shall be 3 in. for 1-in. rivets, $2\frac{3}{4}$ in. for $\frac{7}{8}$-in. rivets and $2\frac{1}{2}$ in. for $\frac{3}{4}$-in. rivets."

Article 320.—The substance of this Article is fully covered in the recommendations affecting Article 319, and should be omitted.

Article 321.—Investigation of a great many cases of fabricated bridges shows that the value of $\frac{l}{r}$ of the segment between connections never exceed the limits set in this Article and, therefore, it is recommended that it be omitted.

Article 323.—In case the distance between rivet lines of the segments is 12 in. or less, single lacing at 60° inclination becomes too crowded. The writer, therefore, would recommend the following wording after the first sentence: "If the distance between the rivet lines of the flanges is less than 12 in., 45° shall be used for single lacing."

Article 327.—The formula given always furnishes a net section larger than the actual net section computed along diagonal lines. For railroad work, $\frac{7}{8}$ in. and larger sizes are used in splices and gusset-plates. The spacing of rivets is generally 3 in. for $\frac{7}{8}$-in. rivets and $3\frac{1}{2}$ in. for 1-in. rivets. Why not, then, change the 4 in. to 3 in. in the formula and avoid calculating net section by this formula for all cases where the spacing of rivets is 3 in. or more from the plane considered. The formula, then, should read $A\left(1-\frac{P}{3}\right)$.

Article 329.—Change to read: "Where necessary to secure the required section or bearing area, pin-holes shall be reinforced by plates. These plates shall be connected so as to transmit and distribute the bearing pressure proportionally over the full cross-section with a minimum of eccentricity. At least one full-width plate on each segment shall extend at least 6 in. beyond the near edge of the stay-plate, due consideration being given to the treatment for forked ends (Article 332)."

Article 330.—Adding two extra lines of rivets for each intervening plate is not logical for all conditions. The writer would recommend that for each intervening plate an excess of 30% of the total number of rivets required, be added.

Article 331.—The statement that the extended filler should be secured by sufficient rivets is indefinite. It is recommended that the extended portion of the filler contain at least 30% of the total number of rivets.

Article 337.—The common understanding of the word "hinged" is a complete pin-hole in the two elements of the shoe. As there is no tendency, ordinarily, for the span to lift off the shoe, there is no necessity for any such arrangement. It is recommended that the word "hinged" be changed to "rocker".

Article 340.—In this Article also, the word "hinged" should be changed to "rocker", and after the word "center of the pin" should be added "or ridge bearing."

Article 341.—In this Article, also, the word "hinged" should be changed to "rocker."

Article 405.—After "stringers in through spans shall be riveted between the floor-beams," add: "and rest on top of floor-beams for deck truss spans." After "shelf angles shall be provided on the floor-beams," add: "where necessary."

Article 406.—Change the heading to read "Stringer Bracing." Change the Article to read: "Top lateral bracing shall be used for stringers when the panel lengths exceed 15 ft. Where two lines of stringers are used under each track in panels more than 20 ft. in length, they shall be connected by cross-frames."

Article 502.—Change to read: "Top lateral bracing shall be provided in all through spans having sufficient head-room, in all I-beam spans over 25 ft. in length, and in deck spans, except plate-girder spans carrying solid floors."

Article 505.—After "lateral" add "and centrifugal."

Article 602.—Add after the words: "centers of gravity" in the first sentence, "and by method in Article 209 for computing compression flanges."

Article 607.—After "wheel load" add "without impact."

Article 608.—Add the sentence: "The splices in flange members, if used, shall be designed with 10% excess."

Article 609.—This should be written more clearly; change the first sentence to read: "Splices in web-plates shall be equal in strength to the moment of the web (one-eighth of the web assumed to act with each flange) and the end shear." Add to Article: "Web-plates shall be symmetrically spliced by plates on each side."

Article 610.—Omit all reference to milling, as this refers to workmanship and is covered in Article 1021. Change this Article to read: "Stiffener angles shall be placed at end bearings and at points of concentrated loads. Such stiffeners shall not be crimped and shall have outstanding legs proportioned for bearing and extending as nearly as practicable to the edge of the flange angles."

Article 615.—The writer would prefer this Article to read as follows: "If through plate girders project 2 ft. or more above the base of the rail, the upper corners shall be rounded. In multiple-span bridges usually only the extreme ends shall be rounded. Exposed ends of through girders shall be neatly finished with end plates."

Article 618.—Change "shall extend 12 in. into the masonry" to "shall extend at least 12 in. into the masonry."

An article should be added relating to camber for plate girders as it is found that there is no uniformity for the various railroads. The writer would

recommend that for girders having a depth greater than one-twelfth of the length of the span, that camber be omitted. If camber is required, it shall be $\frac{1}{1200}$ of the span length.

Article 701.—The writer would recommend that this Article be changed, as follows: "The top chords and end posts shall be made of two segments with a cover-plate and shall have stay-plates and lacing on the open side. The cover-plate shall not exceed $\frac{5}{8}$ in. in thickness and if the section area required, and Article 315, should call for a cover-plate of more than $\frac{5}{8}$ in. in thickness, a symmetrical section shall be selected having transverse diaphragms every 6 to 8 ft., in addition to stay-plates and lacing on the open sides.

Article 703.—Change this Article to read: "For spans up to 200 ft., inclusive, provide camber by increasing the top chord lengths $\frac{1}{8}$ in. per 10 ft. For longer spans, the length of members shall be such that the camber will be equal to the deflection produced by the dead and live loads without impact."

Article 704.—Under unit stresses, the bearing allowed on pins is 24 000 lb. per. sq. in. and tension on rolled shapes 16 000 lb. per sq. in., a ratio of 3 to 2. If the ratio of three-fourths in Article 704 is used, the bearing value on the pin is less than 24 000 lb. The ratio of "3 to 4" should be changed to "2 to 3."

Article 802.—The second sentence, "Bottom struts shall be proportioned to resist stresses produced by temperature changes", is impracticable. The change of length, Δ, of any member due to any stress is given by the following formula:

$$\Delta = \frac{P\,L}{E}$$

in which,

P = unit stress causing deformation,
L = length, in feet,
E = 29 000 000, modulus of elasticity.

The deformation due to changes in temperature varying by 120° Fahr. (or 60° each way), inserted in the formula gives:

$$0.0000065 \times 60 \times L \times 12 = \frac{P\,(L \times 12)}{29\,000\,000}$$

From whence P = 11 310 lb., which is constant for all lengths and all sections of members for given temperature. Therefore, to design the member to resist temperature stresses, the unit stress due to lateral or longitudinal forces must be low, less than 3 000 lb. per sq. in. This method is impracticable and it is recommended that the second sentence read: "Bottom struts shall be proportioned to distribute the calculated shear equally between the two shoes and carry its own weight."

Article 803.—Change to read: "Anchor-bolt holes in column bases shall be large enough to provide for the expansion of the tower bracing."

The writer would recommend that the material coming under the "Structural Grade" be noted to avoid misunderstanding. Therefore, include a sentence at the beginning of Section 9, as follows: "Structural grade includes such materials as plates, shapes, flats, pins, rollers, eye-bars, and forgings."

Article 902.—The structural grade of material has an ultimate strength of 55 000 to 65 000 lb. per sq. in. It has developed from past experience that when the threads are cut, the material is too soft to permit good threads. It is recommended, therefore, that an additional specification be inserted covering material used for rods and bolts, as follows:

Elastic limit	One-half of ultimate
Ultimate	60 000 to 70 000 lb. per sq. in.
Elongation in 8 in	22%
Cold bend	180° $d = t$

One tensile and one bend test from each heat.

Article 902.—The heading "Structural Steel" above the column should be "Structural Grade", inasmuch as this specification covers pins, rollers, eye-bars and forgings, in addition to material ordinarily known as structural steel.

Article 909.—In the first sentence, change "shall bend cold through 180° without cracking" to "shall bend cold through 180° without cracking on the outside of the bent portion."

Articles 910, 911, and 912.—In the first sentence, after the word, "cracking", add, "on the outside of the bent portion."

Article 913.—The broken section in Fig. 4, indicates a circle instead of a rectangular section. Change to broken lines.

Article 934.—Add, after "cracking", "on the outside of the bent portion."

Article 935.—Change the sentence, "Test bars shall be annealed with the castings they represent," to read, "Test bars shall be annealed in contact with the castings they represent."

Article 937.—Change to read: "The castings shall conform substantially to the drawings and be free from injurious defects."

Article 938.—The clause, "and shall be conducted so as not to interfere unnecessarily with the operation of the works", should be omitted as unnecessary.

Article 940.—The heading of this Article should be "Process" and not "Excess."

Article 944.—It is suggested that a drawing of Fig. 1 be shown to obviate the necessity of referring to Serial A48-18, A. S. T. M.

Article 948.—Omit the clause, "and shall be conducted so as not to interfere unnecessarily with the operation of the works."

Article 1001.—This Article should be omitted as it does not mean anything; the specifications determine the workmanship.

Article 1003.—For the sake of brevity, it is suggested that the two classes of work be called "Punched Work" and "Reamed Work." Under (*b*) change, "in this work full punching is allowed only for minor parts" to "in this work full-size punching is allowed for bracing, minor parts, etc., conforming to the requirements of Article 1004 (*a*)."

Article 1004.—Change heading to "Rivet Holes in Punched Work." Under (*a*), change to: "Material not exceeding in thickness the nominal diameter of the rivet plus ⅛ in., may be punched full size." Under (*b*), change to: "If the limitations specified in (*a*) are exceeded, the size of rivets should be increased or the material designed for such thicknesses to meet requirements of

(*a*)." Under (*c*), change to: "All holes shall be punched throughout of one size. Holes for field connections of trusses shall be reamed $\frac{1}{8}$ in. larger in diameter with connecting parts assembled or to metal templates 1 in. thick. Holes for floor-beam and stringer connections shall be reamed $\frac{1}{8}$ in. larger in diameter to a metal template 1 in. thick."

Article 1005.—Change heading to "Full-Size Punching", and change Article to read: "Holes punched and not reamed shall be $\frac{1}{16}$ in. larger than the nominal diameter of the rivets. The diameter of the die shall not exceed the diameter of the punch by more than $\frac{3}{32}$ in." The writer advises the omission of all reference to accuracy of punching, as the tests given are difficult of interpretation. After all, the workmanship is governed by existing practice subject to the judgment of the inspectors.

Article 1006.—Change the heading to "Shearing in Punch Work." The edge distances of holes to sheared edges are given previously, therefore, most of this Article can be omitted. Change the Article to read: "Sheared edges of material more than $\frac{3}{4}$ in. thick when the sheared edges are in tension, shall be planed to a depth of $\frac{1}{4}$ in. Re-entrant cuts shall be filleted before cutting."

Article 1007.—Recently, the writer had occasion to make some tests in sub-punching and reaming $\frac{7}{8}$-in. plates for $\frac{7}{8}$-in. rivets and 1-in. plates for 1-in. rivets. From these tests it is suggested that the Article read as follows:

"*Reamed Work.*—Full-size punching, sub-punching and reaming, and drilling, shall conform to the following:

"(*a*).—Holes in lateral, longitudinal, and sway-bracing, lacing, stay-plates, and diaphragms may be punched full size, provided the material does not exceed in thickness the diameter of the rivets.

"(*b*).—Holes in other material the thickness of which does not exceed the diameter of the rivets shall be sub-punched and reamed. In sub-punching, the diameter of the punch shall be $\frac{3}{16}$ in. less than the nominal diameter of the rivets and the die not more than $\frac{3}{32}$ in. larger than the punch. The reamed holes shall be $\frac{1}{16}$ in. larger than the nominal diameter of the rivets.

"(*c*).—Holes in material the thickness of which is greater than the diameter of the rivets, shall be drilled from the solid."

Article 1008.—The rules for testing accuracy of punching are not practical and are impossible of interpretation in the same manner by different inspectors. The writer would recommend omitting this Article, leaving the accuracy of the work to the judgment of the inspectors.

Articles 1011 and 1012.—These Articles should be omitted as unnecessary.

Article 1016.—Change this Article to read: "Web-plates of girders which have no cover-plates shall be flush or project up to $\frac{1}{8}$ in. above the top flange angles. Web-plates of girders which have cover-plates may be $\frac{1}{2}$ in. less in width than the distance back to back of flange angles. When web-plates are spliced, a clearance of not more than $\frac{3}{8}$ in. between ends of plates will be allowed."

Article 1017.—Omit this Article as unnecessary.

Article 1018.—Change heading to "Screw Threads." Change the word "ends" to "nuts" making the sentence read: "Screw threads shall make close fits in the nuts, etc."

Article 1019.—Change to: "Welds in steel will not be allowed except to remedy minor defects."

Article 1020.—Change the words "hot-straightened" to "straightened", as the thinner plates can be straightened cold.

Article 1021.—It is not necessary to have a bearing under the top flanges of deck girders, as rivets are provided in the flanges to carry the wheel loads. Change the first sentence to read: "Stiffeners at all bearing points shall be milled or ground to bear against flange angles."

Article 1022.—Change to: "Floor-beams for open floor, built-up stringers, and girders having end connection angles shall be faced to exact length after the connection angles are riveted. I-beams for stringers may be faced before connection angles are riveted on. Solid floor connections do not require facing. The thickness of the angles shall not be reduced by facing more than $\frac{1}{8}$ in. at any point."

Article 1023.—Change to: "Abutting joints in compression members, tension members, and girder flanges shall be faced and brought to an even bearing."

Article 1024.—Omit the first sentence as superfluous.

Article 1028.—Omit first and last sentences as unnecessary, retaining only the sentence which allows variation in distance between pin-holes.

Article 1030.—Omit this Article as unnecessary.

Article 1031.—As the mills are limiting the writer's company to rounds up to $5\frac{3}{4}$ in., inclusive, the sizes above this diameter cannot be secured, except as special material. Change "Pins more than 7 in. in diameter" to "Pins more than $5\frac{1}{2}$ in. in diameter."

Article 1103 (b).—At the present time, plates up to and including 48 in. are figured on the basis of their nominal weights. It is recommended that the same limit be used in this Article. In the last sentence, change: "deducting for copes, cuts, and open holes" to "deducting for copes and cuts."

Article 1103 (c).—Change "36 in." to "48 in."

Article 1105 (a).—In the second sentence, add: "as far as practicable" after "shall be packed separately." It is believed that the limit of 300 lb. is too small, as the writer's company makes shipments in barrels of as much as 1 500 lb. It is suggested that the following clause be omitted: "the gross weight of any one of which shall not exceed 300 lb."

Article 1105 (c).—Omit this Article as unnecessary.

Article 1201.—Change this Article to read: "All steelwork not incased in concrete, after it has been accepted by the inspector and before shipment, shall be thoroughly cleaned and given one coat of approved paint. Surfaces inaccessible after erection shall be given two coats of paint in the shop." It is suggested that the Committee specify three or four standard kinds of paints to be used for shop paint. This would be a great help in the shop and the tendency would be to use paint of a higher quality.

Article 1202.—The writer approves this Article, but wishes to add the following sentence: "This refers to material incased in concrete as well as material to be shop painted."

Article 1205.—Omit this Article as unnecessary.

Article 1206.—Change this Article to read: "Finished surface in moving contact shall be coated with white lead and tallow."

Article 1306 (*a*).—Add: "A reasonable amount of drifting or reaming in as the Purchaser pays for special test requested by the Engineer.

Article 1304.—Change the heading to: "Facilities for Testing", inasmuch the field to insure fair holes is permissible and shall be assumed to be a legitimate erection expense."

Article 1401 (*c*).—It is believed that the minimum tensile and yield points for full-size tests should be less than the minimums permitted for mill tests. The writer would suggest that 54 000 minimum tensile and 29 000 minimum yield point be used as given by the A. R. E. A. The figures, 54 000 and 29 000, are inconsistent with those given in Article 905.

Henry B. Seaman,* M. Am. Soc. C. E. (by letter).†—The discussions call attention to the similarity of the Tentative Specifications for Steel Railway Bridges to the recent specifications of the American Railway Engineering Association. This similarity may have been due to the strong representation of that Association on the Committee, and to the courtesy the Committee was inclined to extend. It is a question how far such courtesy should lead. The fields of the two Societies are distinct, as has been suggested by Mr. Guppy and others. The work of this Society is toward professional suggestion, rather than business authority. The authority, as well as the responsibility, must rest with the individual engineer.

It was with this view that the writer offered a preliminary discussion, and, as others have expressed themselves similarly, he feels called on to review the subject further.

The clearance diagram (Fig. 1)‡ was left as adopted by the A. R. E. A., although a simple lower corner might have been preferred. It might have been better to have closed the diagram at the bottom by straight lines, from a point 4 ft. 0 in. above the top of the rail at the side clearance, to a point 2 ft. 6 in. from the side clearance at the top of the rail.

The "engine diagram" (Figs. 2 and 3)§ was adopted in conformity with the Cooper series, which was presented to this Society by its author, the late Theodore Cooper, M. Am. Soc. C. E., on January 3d, 1894.‖

The Committee might have preferred E-50, with the provision for overload, as a standard, but in deference to the A. R. E. A., accepted its specification of E-60 loading, although realizing that the weights had far outgrown the original purpose of Mr. Cooper. The writer has examined with interest a work on engine loading by D. B. Steinman, M. Am. Soc. C. E., who has developed a typical engine of the Mallet type, which is a composite of the heaviest engines now in service. Considering the variety of standards that the different railroads will adopt, however, it might have been better, as Mr. Purdon suggests, to have used the loading of E-10 as a basis (or, similarly, Steinman's M-10), and from this each road could adopt a multiple for its standard. Such a standard might well be 25% in excess of the existing service on the railroads.

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* Cons. Engr., New York City.

† Received by the Secretary, March 28th, 1922.

‡ *Proceedings*, Am Soc. C. E., December, 1921, p. 687.

§ *Ibid.*, p. 688.

‖ "Train Loadings for Railroad Bridges", *Transactions*, Am. Soc. C. E., Vol. XXXI (1894), p. 174.

The suggestion that a bridge should be proportioned for its ultimate load is really the crux of bridge design. It was with this in view that the writer offered a specification to the Society in 1912,* in which the loading of that time, E-40, was increased 25%, to E-50, and, at the same time, the basic unit stress of 16 000 lb. was increased 25%, to 20 000 lb., which was then considered to be the highest stress at which a bridge should be maintained. The recent adoption by the A. R. E. A. of 24 000 lb., or more, as the safe limit, has been accepted with some misgiving, but the fact that the maximum assumed loadings are seldom reached in service is probably the saving feature in the use of this high stress. Although one may prefer that a bridge be proportioned for the ultimate load, a direct specification to that effect does not seem to be practicable under the present system of railroad management. The clause for overload (Article 108), only partly covers this condition, and leaves waste material in the chord sections. It would be better to permit an increase of 50% in the allowable stresses specified, provided the structure, so designed, would carry a like percentage of overload.

In regard to impact, little more need be said. The diagram, Fig. 21, shows the striking agreement between the formula,

$$I = 125 - \frac{1}{8}\sqrt{2\,000\,L - L^2},$$

and the tests. The trial plotting of a modified formula, Fig. 8,† does not give satisfactory results for long spans.

It has been suggested that the new A. R. E. A. impact formula is intended only for spans of 300 ft., or less. This limitation would exclude it from the Tentative Specification, which covers spans of all lengths. By inspection of Fig. 7,‡ it will be noticed that the new A. R. E. A. formula is too high even for short spans from 40 to 120 ft., where plate girders which need no excess of strength, are used, whereas from 120 to 300 ft., where truss spans which need the fullest provision for loading, in anticipation of the allowable overload stress of 24 000 lb., or more, are used, the formula is deficient, notably so for spans of 210 and 300 ft. If the test, giving 22% impact for the lower chord of the 440-ft. span at Bellefontaine,§ is plotted it is found again to be deficient.

The selection of the proper impact formula, however, is only part of the problem of impact on bridges. The relative effect of dead load may be important, but as yet there are no tests for comparison. The effect from multiple tracks must also be considered. The provision that the load for multiple tracks shall be reduced 10%, 20%, or 30%, for two, three, or four tracks, respectively, is crude. The conditions should be susceptible of better analysis.

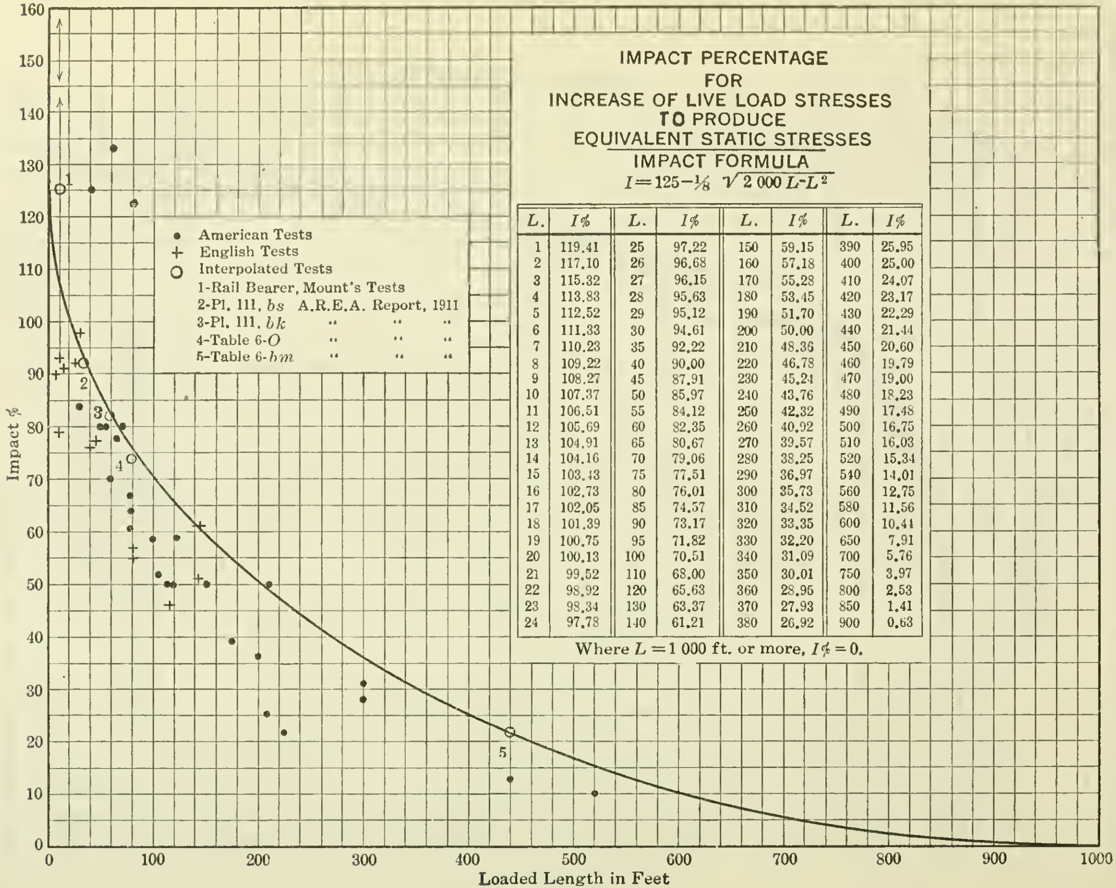
It is known that the impact of the tests is due mainly to the blow of the unbalanced drivers and to the synchronism of the interval of the hammer blow with that of the vibration of the span. The same synchronism from

* *Transactions*, Am. Soc. C. E., Vol. LXXXV (1912), p. 340.

† *Proceedings*, Am. Soc. C. E., December, 1921, p. 715.

‡ *Ibid.*, p. 714.

§ As shown in Column 3, Location 1822, Table 6-*bm*, of the A. R. E. A. Report of 1911.



$$I = 125 - \tfrac{1}{8}\sqrt{2\,000\,L - L^2}$$

L.	I%	L.	I%	L.	I%	L.	I%
1	119.41	25	97.22	150	59.15	390	25.95
2	117.10	26	96.68	160	57.18	400	25.00
3	115.32	27	96.15	170	55.28	410	24.07
4	113.83	28	95.63	180	53.45	420	23.17
5	112.52	29	95.12	190	51.70	430	22.29
6	111.33	30	94.61	200	50.00	440	21.44
7	110.23	35	92.22	210	48.36	450	20.60
8	109.22	40	90.00	220	46.78	460	19.79
9	108.27	45	87.91	230	45.24	470	19.00
10	107.37	50	85.97	240	43.76	480	18.23
11	106.51	55	84.12	250	42.32	490	17.48
12	105.69	60	82.35	260	40.92	500	16.75
13	104.91	65	80.67	270	39.57	510	16.03
14	104.16	70	79.06	280	38.25	520	15.34
15	103.43	75	77.51	290	36.97	540	14.01
16	102.73	80	76.01	300	35.73	560	12.75
17	102.05	85	74.57	310	34.52	580	11.56
18	101.39	90	73.17	320	33.35	600	10.44
19	100.75	95	71.82	330	32.20	650	7.91
20	100.13	100	70.51	340	31.09	700	5.76
21	99.52	110	68.00	350	30.01	750	3.97
22	98.92	120	65.63	360	28.95	800	2.53
23	98.34	130	63.37	370	27.93	850	1.41
24	97.78	140	61.21	380	26.92	900	0.63

Where $L = 1\,000$ ft. or more, $I\% = 0$.

FIG. 21.

a second train is manifestly impossible. The second train would be more likely to destroy the synchronism of the first train than to augment it. Under these circumstances there should be but little additional impact from the second train. In estimating impact from the second train, it would be better,

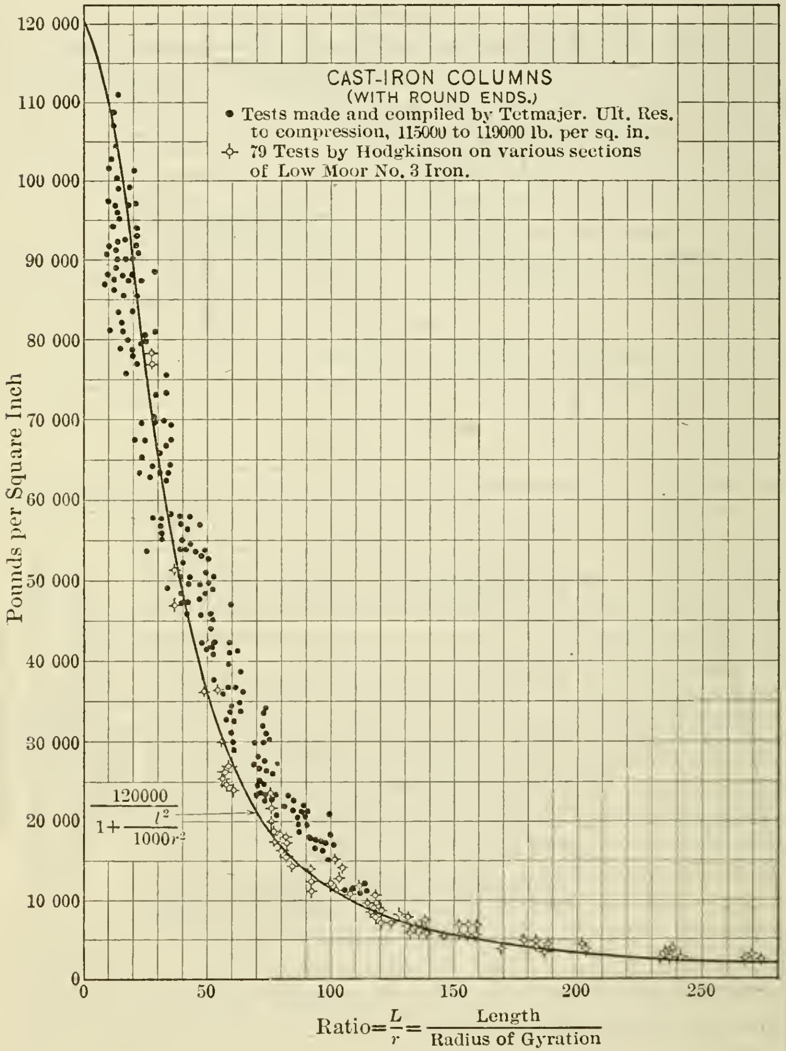


FIG. 22.

after using full impact from the first train, to use the aggregate loaded length of both tracks for the value of L, somewhat as was done in the A. R. E. A. specification of 1910. For tracks in reverse operation (as the second track in two-track bridges, and the third and fourth tracks in four-track bridges), only the uniform train load, without impact, should be used; and in order to avoid

unnecessary refinement in calculations, only full panel loads at the panel points should be considered. All bridges should be designed for possible "left-hand" train service.

The clause (Article 16) on ballasted floors has been inserted without modification, but it is not clear why impact, which is added to cross-ties, should not be also added to ballasted floors.

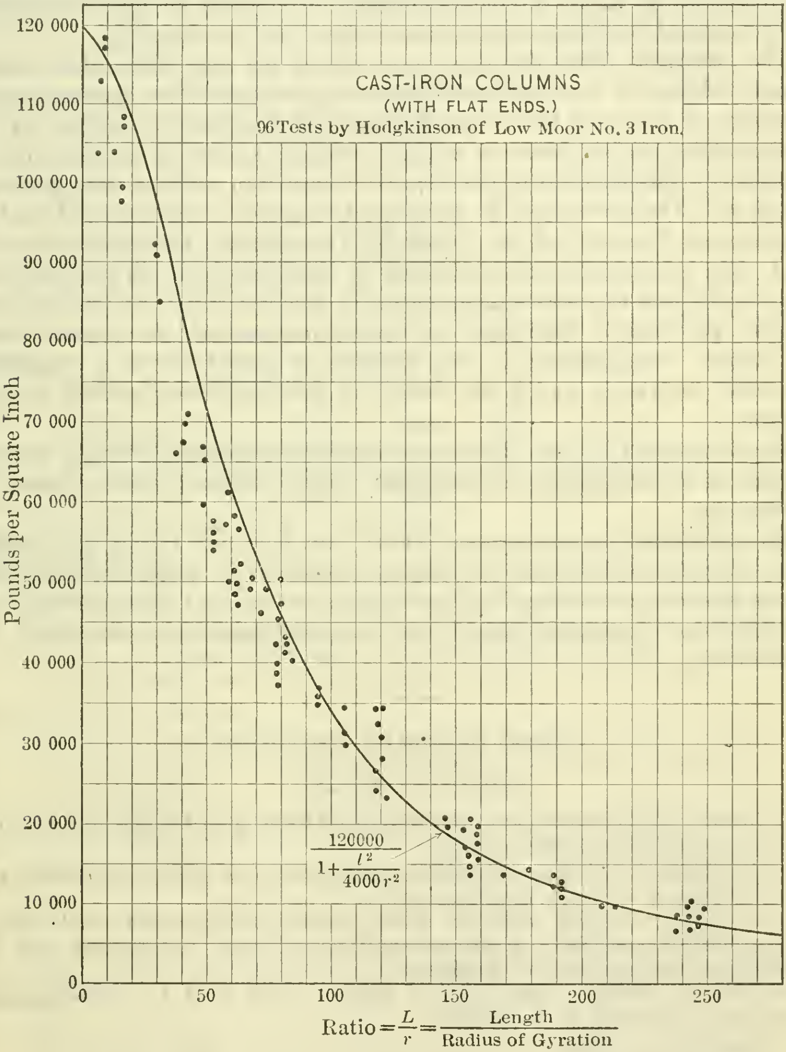


FIG. 23.

Since the early days of bridge design, the longitudinal force has been considered as due to a coefficient of friction of 20 per cent. A thorough investigation of this subject, some years ago, convinced the writer that this was an error, and that the specification was honored more in its breach than in its observance. In his specification, previously mentioned, and for reasons then

expressed, a coefficient of 10% was adopted, and this, he believes, is higher than necessary.

The old column formula of the A. R. E. A.,

$$p = 16\,000 - 70\,\frac{l}{r},$$

had been thoroughly established in practice; yet, because it had been abandoned by the A. R. E. A., the Committee, in courtesy to that Association, did not suggest it with the three others offered for consideration.

The strongest claim that has been offered for any practicable column formula, whether it is the straight line or the parabola, is its agreement with the results of full sized tests. The Schwarz, the Gordon, the Rankine, or the Euler-modified, or by whatever name it may be known in its long line of endorsement, surpasses any of the others in comparison with the tests, as shown in Fig. 9.* The correctness of the general formula is strikingly depicted in the diagrams, Figs. 22 and 23, of tests by Tetmajer and Hodgkinson, on cast iron.† The homogeneity of the material in these tests, and the freedom from irregularities due to workmanship, make the comparison of the formula with the tests particularly instructive as illustrating the law of column flexure and failure. This formula is of a rational, if indeed not of a completely theoretical, derivation, and is the oldest and best established formula in general use.

The discussion‡ of Mr. Hovey, on latticing of columns, offers a definite solution of a perplexing and important detail. It may well be used in specifications.

The calculation of net sections, where rivet holes are zigzag, is a simple matter if one considers that the diagonal section is in shear, and estimates shear in this case, as in others, as three-fourths the value of direct tension.

With these introductory remarks the following suggestions are offered for consideration.

STEEL RAILWAY BRIDGES

Section A.—General

1.—These specifications cover the design of fixed span bridges and require first-class design and workmanship.

2.—Drawings to Govern.—Drawings shall govern in cases where they are not in agreement with the specifications.

3.—Material.—Bridges shall be made wholly of structural steel except where otherwise specified. Castings shall be of steel, unless cast iron is specifically authorized by the Engineer.

4.—Type of Bridge.—The type of bridge to be used for various span lengths may preferably be as follows:

Rolled beams up to........................	35 ft.
Plate girders from........................	30 to 125 ft.
Riveted trusses from......................	100 ft. and over.
Pin-connected trusses from................	150 ft. and over.

* *Proceedings,* Am. Soc. C. E., December, 1921, p. 719.

† Plotted by A. J. Malukoff, Assistant Engineer, Department of Bridges, New York City.

‡ See p. 922.

5.—Number of Trusses.—For double-track through bridges, two trusses shall be used. Four-track bridges may be constructed as two double-track bridges, side by side, or may have three trusses, as directed.

6.—Spacing of Trusses.—The width between centers of trusses or girders shall be sufficient to prevent overturning by the specified lateral forces and in no case less than one-twentieth of the span.

7.—Clearance.—The clearance on straight track shall not be less than that shown in Fig. 24. On curves, additional provision shall be made for a car, 80 ft. long, 60 ft. between truck centers, 14 ft. high above the top of a 6-in. rail, and with allowance for super-elevation of the outer rail. Unless otherwise specified, the super-elevation of the outer rail shall be ¾ in. for each degree of curvature, with a maximum of 6 in.

8.—Skew Bridges.—In skew bridges without ballasted floors, the end stringers or end girders for each track shall be square to the line of track.

9.—Timber Floor.—Ties shall not be less than 10 ft. long, spaced not more than 6 in. apart, and secured against bunching. If subjected to bending, the stress in the extreme fibers of ties shall not exceed the unit stress for timber given in Article 202, assuming a maximum wheel load, with 125% impact, to be distributed over three ties.

10.—Ballasted Floors.—Floors consisting of beams transverse to the axis of the structure, shall be designed for a uniform load per linear foot of each track, equal to one-third the heaviest wheel concentration of the engine.

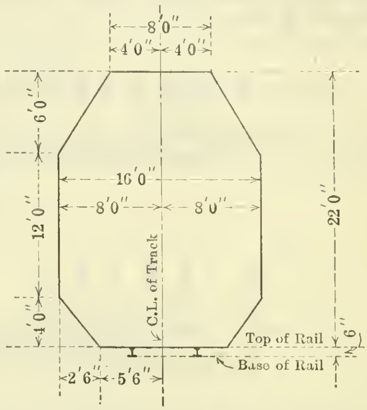


Fig. 24.

11.—Dimensions for Calculations.—For the calculation of stresses, the length shall be:

For trusses and girders, the distance between centers of bearings;
For floor-beams, the distance between centers of trusses;
For stringers, the distance between centers of floor-beams;

and the depth shall be:

For pin-connected trusses, the distance between centers of pins;
For riveted trusses, the distance between the centers of gravity of the chords;
For plate girders, the distance between the centers of gravity of the flanges (not to exceed out to out of flange angles).

12.—Spans with floor systems shall preferably have end floor-beams.

Section 1.—Loads and Stresses

101.—Weight of Materials.—In estimating the weight of the structure, for the purpose of computing stresses therein, the following unit weights shall be used:

Steel	490 lb. per cu. ft.
Concrete	150 " " " "
Sand and gravel......................	100 " " " "
Asphalt-mastic	150 " " " "
Bituminous macadam..................	130 " " " "
Granite	170 " " " "
Paving bricks........................	150 " " " "
Ballast	120 " " " "
Timber	4½ " per ft. B. M

The rails and fastenings shall be assumed to weigh 150 lb. per lin. ft. for each track.

102.—Loads.—Stresses shall be shown separately for the following: Dead load, live load, impact, centrifugal force, and lateral and longitudinal forces. Members shall be proportioned for the combination giving maximum sections, except as otherwise provided.

103.—Dead Load.—The dead load shall consist of the entire weight of the superstructure, estimated in accordance with the unit weights given in Article 101.

104.—Live Loads.—The live load for each track shall consist of typical engines followed by a uniform train load, according to either Cooper's series, or Steinman's series, as may be specified by the Engineer. It shall be a multiple of one or the other of the loads with wheel spacings, as shown in Fig. 25 or Fig. 26.

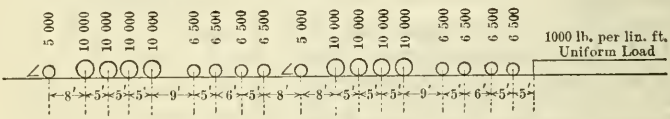


FIG. 25.

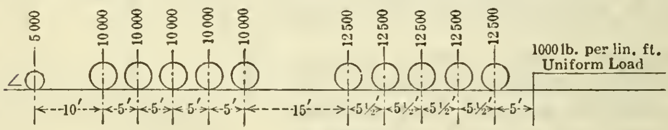


FIG. 26.

Loading M-50 is recommended for main-line bridges of American railways.

105.—Impact.—The increase of live load stresses to produce equivalent static stresses shall be determined by Table 8.

TABLE 8.—IMPACT FORMULA.

$$I = 125 - \tfrac{1}{8}\sqrt{2\,000\,L - L^2}$$

L.	*I*%	*L.*	*I*%	*L.*	*I*%	*L.*	*I*%
1	119.41	25	97.22	150	59.15	390	25.95
2	117.10	26	96.68	160	57.18	400	25.00
3	115.32	27	96.15	170	55.28	410	24.07
4	113.83	28	95.63	180	53.45	420	23.17
5	112.52	29	95.12	190	51.70	430	22.29
6	111.33	30	94.61	200	50.00	440	21.44
7	110.23	35	92.22	210	48.36	450	20.60
8	109.22	40	90.00	220	46.78	460	19.79
9	108.27	45	87.91	230	45.24	470	19.00
10	107.37	50	85.97	240	43.76	480	18.23
11	106.51	55	84.12	250	42.32	490	17.48
12	105.69	60	82.35	260	40.92	500	16.75
13	104.91	65	80.67	270	39.57	510	16.03
14	104.16	70	79.06	280	38.25	520	15.34
15	103.43	75	77.51	290	36.97	540	14.01
16	102.73	80	76.01	300	35.73	560	12.75
17	102.05	85	74.57	310	34.52	580	11.56
18	101.39	90	73.17	320	33.35	600	10.44
19	100.75	95	71.82	330	32.20	650	7.91
20	100.13	100	70.51	340	31.09	700	5.76
21	99.52	110	68.00	350	30.01	750	3.97
22	98.92	120	65.63	360	28.95	800	2.53
23	98.34	130	63.37	370	27.93	850	1.41
24	97.78	140	61.21	380	26.92	900	0.63

in which,

I = percentage to be added to live load stresses.
L = length, in feet, of that part of the span which has been loaded to produce the maximum live load stress.

For bridges with multiple tracks, the track nearest the truss shall receive full impact as per Table 8; the second track, with service in the same direction, shall receive impact for the aggregate loaded length of the two tracks; a third track, with service in the same direction, shall receive impact for the aggregate loaded length of three tracks, etc. The calculations for tracks with service in the opposite direction shall be for full panel load concentrations of the uniform train only, without impact. All bridges shall be designed for possible "left-hand" train operation.

106.—For bridges designed exclusively for electric traction, the impact shall be taken as one-third of that given by Table 8. Impact shall not be added to stress produced by longitudinal or lateral forces.

107.—*Overload.*—Provision for 50% overload shall be made, as provided in Article 201.

108.—*Centrifugal Force.*—Structures on curves shall be designed to resist the centrifugal force of the live load applied 6 ft. above base of rail, as computed by the following formula:

$$C = \frac{0.067\ W\ V^2}{R}$$

in which,

C = horizontal centrifugal force;
W = live load, including impact;
R = radius of curve (5730 ÷ degree of curve);
V = speed, in miles per hour (60 — $2\frac{1}{2}$ degree of curve).

109.—*Wind Pressure.*—The structure shall be designed to resist a wind pressure, acting in either direction horizontally, of 30 lb. per sq. ft. of surfaces, as seen in elevation, the floor system, considered solid area, one truss complete, and one-half the surface of all remaining trusses (but never less than 200 lb. per lin. ft. of loaded chord, and 150 lb. per lin. ft. of unloaded chord), as well as that of a train 14 ft. high. The pressure on the train, as well as one-half the pressure on the structure, shall be considered as a moving load.

110.—If a wind pressure of 50 lb. per sq. ft. of unloaded structure would produce greater stresses than the loading specified in Article 109, such stresses shall be used.

111.—In calculating the stresses due to wind forces on viaduct towers, the viaduct shall be considered as loaded on the leeward track with empty cars, of weight only sufficient to prevent overturning, with a wind pressure of 500 lb. per lin. ft., acting 7 ft. above top of rail.

112.—*Longitudinal Force.*—Provision shall be made for the starting and stopping of trains, with a coefficient of friction on the engine drivers at 20% and on the balance of the train at 10 per cent.

113.—*Temperature.*—On simple spans, provision shall be made for expansion due to a variation in temperature of 120° Fahr. (On statically indeterminate structures of more than 300 ft. span, a difference of 40° Fahr., between the shaded and the unshaded chords shall be provided for.)

114.—*Stress Sheets.*—The stresses for each loading shall be calculated separately and shown on a stress sheet. The results shall be combined, and the maximum stresses in either direction deduced therefrom.

115.—*Alternate Stresses.*—Members subject to alternate stresses of tension and compression shall be proportioned for the stress giving the largest section, and designed to resist each stress. If the alternate stresses occur in immediate succession, each stress shall be increased by 50% of the smaller. The connections, in either case, shall be proportionated for the arithmetical sum of the stresses.

116.—Combined Stresses.—Members subject to both direct and bending stresses shall be proportioned so that the combined fiber stress shall not exceed the allowable stress specified, properly reduced, in cases of long compression members. The stresses in the outer fiber of solid built members, except plate girders, shall be computed by the moment of inertia of the section. In continuous upper chords of deck bridges carrying the floor, the bending stress due to the live load shall be computed from a moment equal to three-quarters of the maximum moment produced on a span of one panel length considered as a simple beam.

117.—Secondary Stresses.—Secondary stresses shall be avoided wherever possible, in designing. In trusses without sub-paneling no account need be taken of secondary stresses in a member the width of which in the plane of the truss, is less than one-tenth of its length. Where this ratio is exceeded or where sub-paneling is used, secondary stresses due to the deflection of the truss shall be computed.

Section 2.—Unit Stresses

201.—In proportioning the several parts of the structure the following allowable stresses shall be increased 50%, and the structure designed to carry a live load 50% greater than that specified in Article 104.

Allowable Stresses for Structural and Rivet Steel:

	Pounds per square inch.
Tension	16 000
Compression (one diameter)	16 000
Compression, on columns, as per Table 9:	

TABLE 9.—Working Stresses for Columns.

$$p = \frac{16\,000}{1 + \dfrac{l^2}{13\,500\, r^2}}$$

$\frac{l}{r}$	p	$\frac{l}{r}$	p	$\frac{l}{r}$	p	$\frac{l}{r}$	p	$\frac{l}{r}$	p
40	14 300	68	11 920	96	9 510	124	7 480	185	4 530
42	14 150	70	11 740	98	9 350	126	7 350	190	4 350
44	13 990	72	11 560	100	9 190	128	7 230	195	4 190
46	13 830	74	11 380	102	9 040	130	7 110	200	4 040
48	13 670	76	11 210	104	8 880	135	6 810	205	3 890
50	13 500	78	11 030	106	8 730	140	6 520	210	3 750
52	13 330	80	10 860	108	8 580	145	6 250	215	3 620
54	13 160	82	10 680	110	8 430	150	6 000	220	3 490
56	12 980	84	10 510	112	8 290	155	5 760	225	3 370
58	12 810	86	10 340	114	8 150	160	5 520	230	3 250
60	12 630	88	10 170	116	8 010	165	5 300	235	3 140
62	12 450	90	10 000	118	7 870	170	5 090	240	3 040
64	12 270	92	9 830	120	7 740	175	4 890	245	2 940
66	12 100	94	9 670	122	7 610	180	4 710	250	2 840

l = length of column, in inches; r = least radius of gyration of cross-section, in inches.

	Pounds per square inch.
Bending, beams, outer fiber	16 000
Bending, pins, rivets, and bolts	24 000
Shear, plate-girder web, net section	12 000
Shear, pins, and power-driven rivets	12 000
Shear, hand-driven rivets, and turned bolts	10 000
Bearing, pins, rivets, and bolts. (For countersunk rivets, half the depth of countersink shall be omitted when calculating bearing area)	24 000
Bearing, rollers, per linear inch	600 d

in which:

d = diameter of roller, in inches.

Compression on columns shall not exceed that allowed for $\frac{l}{r} = 40$.

For cast steel in shoes and pedestals the allowable unit stresses for structural steel will apply.

For 3.25% nickel steel, or an equivalent alloy steel, with a yield point of 50 000 lb. per sq. in., the allowable stresses may be increased 50%; and, generally, for members composed entirely of steel of greater strength, the allowable stresses for structural steel will be increased in proportion to the higher yield point of the stronger steel.

202.—Allowable Fiber Stress on Wooden Cross-Ties.—(The maximum wheel load, with 125% impact, will be distributed over three ties):

	Pounds per square inch.
White oak, and long-leaf yellow pine................	2 000
Dense Douglas fir....................................	1 500
White pine, short-leaf yellow pine, and spruce........	1 200

203.—Allowable Pressure on Masonry.—

	Pounds per square inch.
Granite masonry	800
Limestone, good quality..............................	600
Sandstone	400
Concrete (1 : 2 : 4)..................................	600

204.—Allowable Pressure on Soils.—Wherever practicable, special tests of bearing value of the soil will be made, but in the absence of more definite information, the following pressures may be allowed:

	Pounds per square foot.
Sound ledge rock....................................	30 000
Hardpan, or compact gravel..........................	16 000
Coarse sand, or gravel..............................	12 000
Clean sand, or dry clay.............................	8 000
Clay (moist)...	4 000
Soft alluvial soil...................................	1 000

On deep foundations allowance may be made for buoyancy and friction.

205.—Allowable Pressure on Wooden Piles.—Piles shall not be placed closer than 2 ft. 6 in., centers, and will be generally designed to sustain 30 000 lb. per pile. Their supporting power, when driven, will be estimated as follows:

(*a*).—When the pile is driven to refusal and supports the load by end bearing only, without friction, allow 1 200 lb. per sq. in. of smallest cross-section, properly reduced for column length when not braced.

(*b*).—When driven to resistance by hammer blows,

$$p = \frac{2\,W\,h}{d + 1}$$

(*c*).—When driven by water jet, or in soft material,

$$p = (S\,a + R)\,L$$

in which:

p = safe load per pile, in pounds;
W = weight of hammer, in pounds;
h = height of fall of hammer at last blow, in feet;
d = penetration under last blow, in inches;
S = shin surface of pile in ground, in square feet; and
L = length of pile in ground, in feet.

$S\,a\,L$ represents the resistance due to skin friction. $R\,L$ represents the value of end bearing, including buoyancy, for a diameter of 12 in. at the point of the pile and should be proportionately reduced for smaller sections.

For loam and silt....................	$a = 1.7$	$R = 47$
For moist clay......................	$a = 7.4$	$R = 96$
For sand, or clay..................	$a = 19.2$	$R = 203$
For coarse sand and gravel........	$a = 29.0$	$R = 300$

Section 3.—Design of Details

301.—Thickness of Material.—Material less than ⅜ in. in thickness shall not be used, except for fillers.

302.—Open Details.—Details shall be arranged so as to give free access for inspection and painting. Water-pockets shall be avoided.

303.—Rigid Members.—Hip verticles and members performing similar functions, and the two end panels of the bottom chords of single-track pin-connected bridges shall be rigid.

304.—Viaduct Struts.—The struts at the base of viaduct towers shall be of sufficient strength to slide the movable shoes when the track is unloaded.

305.—Strength of Details.—In no case shall the details be of less strength than the member as designed.

306.—Net Sections.—Net sections shall be used, in all cases, in calculating tension members, and, in deducting rivet holes they shall be taken as ⅛ in. larger than the nominal diameter of the rivet. In calculating net sections having rivets staggered, all rows shall be deducted unless arranged so that the net section along a zigzag line, taking all distances on the diagonal as of three-quarters their value, exceeds the corresponding net section across the plate.

307.—Pin-connected riveted tension members shall have a net section back of the pin-hole, parallel to the axis of the member, of not less than the required net section of the body of the member, and shall have a net section through the pin-hole at least one-third larger than the required section. Riveted tension members shall be stitch-riveted where necessary to make a compact member.

308.—Maximum Length of Rivet.—The total thickness of plates connected by rivets shall not exceed six times the nominal diameter of the rivet to be used.

309.—Pitch of Rivets.—Rivets shall be proportioned by their nominal diameter. They shall not be spaced, center to center, closer than three diameters nor farther apart, in the direction of stress, than sixteen times the thickness of the thinnest outside plate connected, nor farther apart, at right angles to the line of stress, than thirty times that thickness, except in the cover-plates of compression members, where the spacing may be forty times the thickness of the thinnest plate. The pitch of rivets at ends of built compression members shall not be more than four diameters, for a distance of 1¼ times the width of the member.

310.—Edge Distance of Rivets.—Rivets shall not be spaced closer to sheared edges than 1¾ diameters, nor to rolled edges, than 1½ diameters, nor farther from the side than eight times the thickness of the plate.

311.—Field Rivets.—Field rivets shall be reduced to a minimum.

312.—Built Chord Splices.—Built chords, when faced for bearing, shall be spliced on four sides sufficient to hold the abutting members accurately in place and to transmit 50% of the stress through splice plates. All other joints shall be fully spliced.

313.—Extra Rivets in Packing.—Where stress is transmitted through packing material, it shall be extended for extra riveting. Two extra lines shall be used for each intervening plate.

314.—Bolts.—Where bolts are allowed instead of rivets the holes shall be reamed or drilled and the bolts turned to a driving fit, with full-length bearing and a ¼-in. washer under the nut.

315.—Latticing Compression Members.—All segments of members in compression, connected by latticing only, shall have batten plates at each end. The thickness of such plates shall not be less than one-fortieth of the distance between the rivets connecting them to the compression member. In no case shall the length of such batten plates be less than $1\frac{1}{4}$ times the width of the member. Where intermediate batten plates are used they shall be at least three-quarters of that distance.

316.—The distance between the connections of latticing shall be such that the individual members between them, composing the column, shall be stronger than the colmun as a whole.

317.—Single lattice-bars shall generally be inclined at an angle of 60° with the axis of the member, and double lattice-bars, at an angle of 45°, riveted at the intersection. Single lattice-bars shall have a thickness of not less than one-fortieth, and double lattice-bars not less than one-sixtieth, of the distance between rivets connecting them to the compression member.

318.—The latticing of compression members shall be proportioned to resist shearing stress normal to the member not less than that calculated by the formula:

$$R = \frac{4\,P\,l}{13\,500\,y}$$

in which,

P = the strength of the column as a compression member;
l = length of column;
y = distance from the neutral axis to the extreme fiber.

319.—The diameter of the rivets shall not exceed one-third the width of the bar.

320.—Reinforcing Pin-Holes.—Pin-holes shall be reinforced by plates, if necessary, and at least one plate shall be as wide as the flanges will allow, and be on the same side as the angles. Pin-plates shall contain sufficient rivets to distribute their part of the pin pressure to the full cross-section of the member.

321.—Forked Ends.—Forked ends of compression members should be avoided. Where forked ends are used, a sufficient number of pin-plates shall be provided to give each jaw the full strength of the compression member. At least one of these plates shall extend to the far edge of the batten plates, and the others not less than 6 in. beyond the near edge of the batten plates.

322.—Floor-Beam Connections.—Floor-beams shall be square to the girders or trusses, and shall be riveted directly to the girders or to the posts of the trusses.

323.—Lateral Bracing.—Each main panel of deck bridges shall be provided with intermediate sway-bracing of sufficient section to carry one-half the maximum increment due to moving loads.

324.—Through bridges shall be provided with post brackets at the intermediate panel points, of sufficient strength to maintain the panel in a vertical position under the specified wind pressure, or, when the height of the top chord is more than 26 ft. above the floor, an overhead system of sway-bracing shall be used.

325.—In either deck or through bridges, the end sway-bracing shall be proportioned to carry the entire upper lateral stress to the support, through the end post of the truss.

326.—Rigid lateral bracing is preferred and no connection shall have less than three rivets.

327.—Where adjustable rods are used, open turnbuckles shall be provided and the rods shall be designed to receive an initial stress of 10 000 lb. No rod shall be less than $1\frac{1}{2}$ sq. in. in sectional area.

328.—Plate Girders.—The girders of deck bridges and the stringers of through bridges shall not be spaced closer than 6 ft. 6 in. between centers.

329.—Plate girders shall be proportioned by assuming that the flanges are concentrated at their centers of gravity, but in no case beyond the back of the flange angles. One-eighth of the gross section of the web may be considered as flange area, provided the web is properly spliced to transmit its bending moment.

330.—The gross section of the compression flange shall not be less than the gross section of the tension flange. The flange angles shall form as large a part of the flange area as practicable.

331.—When flange plates are used, at least one flange plate shall extend the full length of the girder, and, on through bridges, an end and corner cover plate shall be used. Any additional flange plates shall be of such length as to allow two rows of rivets of the regular pitch to be placed at each end of the plate, beyond the theoretical point required, and there shall be a sufficient number of rivets at the ends of each plate to transmit its stress value before the theoretical point of the next outside plate is reached.

332.—Where flange plates are of different thicknesses, the thinner plates shall be placed outside of the thicker ones.

333.—Flange plates, subject to either tension or compression, which are spliced, shall be properly covered by extra material equal in section to the material spliced. Flange angles shall have angle splices. There shall be a sufficient number of rivets on either side of the splice to transmit the stress value of the parts cut.

334.—The upper flange shall be rigidly braced at intervals not to exceed twelve times the width. When this is impracticable, the allowable compressive flange stress shall be reduced in accordance with the column formula.

335.—The webs of plate girders, wherever cut, shall be fully spliced for shear and bending, by a plate on each side of the web.

336.—Stiffeners shall be placed at all points of concentrated loading. Where the thickness of the web is less than one-sixtieth of the unsupported distance between flange angles, stiffeners shall be riveted on both sides of the girder, with the outstanding leg as broad as the flange angles will allow. The distance from center to center of stiffeners should not be more than the depth of the full web plate, but, in no case, shall they be closer than 4 ft., nor farther apart than 8 ft. Stiffeners over bearings and at points of concentrated loading shall be packed straight and shall be milled to tight bearing against the flange angles.

337.—*Expansion Rollers.*—All bridges 80 ft. in length or more that bear on masonry, shall be provided with adjustable bearing bolsters, and at one end, shall have turned rollers not less than 4 in. in diameter, placed between two planed surfaces. For spans of less than 80 ft., planed bolsters shall be used, without rollers.

338.—The nests of rollers shall be designed so as to prevent displacement, and to be kept dust free.

339.—*Wall Plates.*—Wall plates may be rolled, cast, or built up, and shall be designed so as to distribute the load uniformly over the entire bearing area.

340.—*Bearings Anchored.*—Trusses shall be secured against side motion on bearing plates and rollers. The bolster blocks shall be joined to the trusses and the bearing plates secured to the underlying supports by bolts. Anchor-bolts shall not be less than $1\frac{1}{4}$ in. in diameter, and shall extend not less than 12 in. into the masonry. Washers shall be used under the nut. Anchor-bolts subjected to tension, as in trestle towers, shall engage 50% more masonry than is sufficient to prevent overturning.

341.—*Eye-Bar Packing.*—Eye-bars shall not be packed out of line with the axis of the member more than $\frac{1}{16}$ in. to 1 ft. Members packed on pins shall be held against side movement by filling rings. The pin shall be of sufficient length to give full bearing to all members, and secured in position.

342.—Camber.—The length of truss members shall be such that the camber will be equal to the deflection produced by the dead load plus one-half the live load, without impact.

Section 10.—Workmanship

1001.—General.—All workmanship shall be first-class. All parts exposed to view shall be neatly finished. All structural bolts shall have hexagonal nuts.

1002.—Straightening.—Material shall be straightened by methods that are not injurious.

1003.—Sheared Edges.—Sheared plates, exceeding $\frac{3}{4}$ in. in thickness, shall have $\frac{1}{4}$ in. planed from their edges.

1004.—Rivet Holes.—Rivet holes shall be so accurately spaced and punched that no variation of more than $\frac{1}{16}$ in. will occur on assembling. Variations of $\frac{1}{8}$ in. may be cause for rejection. Holes must be reamed to match. Drifting will not be allowed.

1005.—In punching, the diameter of punch shall not exceed by more than $\frac{1}{16}$ in. the diameter of rivet to be used, and the diameter of the die shall be small enough to punch a clean hole. Material more than $\frac{3}{4}$ in. thick shall be sub-punched and reamed, or drilled from the solid.

1006.—Sub-Punching and Reaming.—Where sub-punching and reaming is required, the diameter of punch shall be $\frac{3}{16}$ in. smaller than the nominal diameter of the rivet, and the holes reamed after assembling to a diameter $\frac{1}{16}$ in. greater than the diameter of the rivet. Outside burrs shall be removed.

1007.—Assembling.—The parts of riveted members shall be drawn firmly together by bolts before riveting.

1008.—Riveting.—Rivets shall be uniformly heated to a light cherry red before driving. They shall completely fill the holes and shall be driven until dull red or black. Pneumatic hammers shall be used in preference to hand driving.

1009.—Lattice-Bars.—The ends of lattice-bars with single rivets shall be neatly rounded.

1010.—Web Stiffeners.—Stiffeners shall fit neatly against the flange angles. At bearing points and points of concentrated loading on the flanges, the ends of stiffeners shall be faced and brought to true bearing against the flange angles.

1011.—Splice Plates and Fillers.—Web splice plates, and fillers under stiffeners, shall fit within $\frac{1}{8}$ in. of the flange angles.

1012.—Web Plates.—Web plates of girders, which have no cover plates, shall be flush with the top flange angles. When web plates are spliced, there shall not be more than $\frac{1}{4}$ in. clearance between the ends of the adjacent plates.

1013.—Floor-Beams and Stringers.—The main sections of floor-beams and stringers shall be of exact length after riveting, and the end-connection angles accurately set to length, and square.

1014.—Members to Be Straight.—The several pieces forming one built member shall be straight and shall fit closely together. Finished members shall be free from twists, bends, or open joints.

1015.—Finish of Joints.—Abutting joints shall be fitted close. In compression joints which depend on contact bearing, the surface shall be accurately faced so as to provide uniform contact.

1016.—Field Connections.—Holes for floor-beams and stringer connections shall be sub-punched, and reamed to a metal template not less than 1 in. thick. Where practicable, compression members of trusses shall be assembled in the shop, the abutting ends brought to forcible contact, the rivet holes reamed, and the members then match-marked before being taken apart.

1017.—Turned Bolts.—Generally, the use of bolts instead of rivets will not be permitted. Wherever bolts are used, the holes shall be reamed parallel

and the bolts turned to a driving fit, and the threads shall be entirely outside the holes. A washer, not less than $\frac{1}{4}$ in. thick, shall be used under the nut and the thread burred.

1018.—Eye-Bars.—Eye-bars shall be straight and true. The heads shall be made by upsetting and forging. Welding will not be allowed. The form of the head may be determined by the dies at the works where the eye-bars are made, if satisfactory to the Engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of the head and neck shall not be more than $\frac{1}{8}$ in. greater than that of the bar.

1019.—Boring Eye-Bars.—Before boring, each eye-bar shall be properly annealed and straightened. The holes shall be in the center of the head and on the center line of the bar. Bars in the same member shall be bored at the same temperature and, if practicable, shall be piled together and bored at both ends in one operation, and the bars then properly marked for erection. The diameter of the pin-hole shall not exceed the diameter of the pin more than $\frac{1}{50}$ in., for pins 8 in. in diameter or less, nor more than $\frac{1}{32}$ in. for larger pins.

1020.—Pin-Holes.—Pin-holes in compression members shall be bored in one operation. They shall be on the center line and at right angles to the axis of the member, unless otherwise required. The diameter of the pin-hole shall not exceed that of the pin by more than $\frac{1}{50}$ in., for pins 8 in. in diameter or less, nor more than $\frac{1}{32}$ in. for larger pins.

1021.—Pins and Rollers.—Pins more than 7 in. in diameter shall be forged and annealed. Pins and rollers shall be accurately turned to gauge, and shall be straight, smooth, and free from flaws. Pins 9 in. or more in diameter shall have a 2-in. longitudinal hole bored through the axis.

1022.—Screw-Threads.—Screw-threads shall be filleted at the bottom and shall be a tight fit in the nuts. They shall be U. S. Standard.

1023.—Steel Castings.—Steel castings shall be annealed and be free from large and injurious blow-holes.

1024.—Welds.—Welds in steel members will not be allowed.

1025.—Bed-Plates.—Expansion bed-plates for rollers shall be planed true and smooth. Cast wall-plates shall be planed on top. The finishing cut of the planing tool shall be in the direction of expansion.

1026.—Pilot Nuts.—Two pilot and two driving nuts shall be furnished for each size of pin.

1027.—Field Rivets.—Field rivets shall be furnished to the amount of 15% plus 10 rivets, in excess of the nominal number required of each size and length.

1028.—Shipping Details.—Pins and small parts shall be protected for shipment.

1029.—Variation in Section.—There shall be no variation in section from that specified, of more than $2\frac{1}{2}$ per cent.

1030.—Weight.—The scale weight of main members shall be marked in plain figures.

1031.—Finished Weight.—Payment on pound price contracts shall be made by scale weight, including field rivets. Not more than $1\frac{1}{2}$% of the total computed weight of the structure will be allowed for excess weight. Any member weighing $2\frac{1}{2}$% less than the computed weight may be rejected.

1032.—Shop Painting.—All surfaces that come in contact or that are closed shall receive one coat of approved paint before being assembled. All steel shall be scraped free of scale and shall receive one coat of approved paint before leaving the shops, and one coat after erection.

1033.—All turned or faced surfaces shall receive a coat of white lead and tallow before leaving the shops.

In closing this discussion, it may be stated that, on organizing, the Committee suggested that its Chairman write a specification which should be submitted to the Committee for review. The Chairman at that time did not feel prepared for such an undertaking, and preferred to divide the work between seven sub-committees. The discussions within the Committee since then have been such a liberal education on the subject that the foregoing memoranda are now submitted to the Committee for its consideration.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

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ODORS AND THEIR TRAVEL HABITS

Discussion*

By Louis L. Tribus, M. Am. Soc. C. E.†

Louis L. Tribus,‡ M. Am. Soc. C. E. (by letter).§—The discussions|| confirm the writer's opinion, that only through the development of trained observers working along the same lines can intelligent classification be reached and anything approaching mathematical precision be attained.

The writer did not attempt any real definition of what constitutes differences between offensive and agreeable odors, or between those that may be harmful and those that are benign. He merely sought to outline the subject to which others might add data and from which, with later additions, helpful facts and conclusions might be taken. The results have warranted the hope.

Mr. Hansen enlarges on the point that certain industries must be considered essential, and thus be tolerated, while all effort should be made to cure the attending evils; also, that odors are most apt to be the barometer by which the public rates them. He offers zoning as one of the means of relief, but not as a cure.

Professor Whipple discusses interestingly, the personnel of odors themselves and treats the subject along the following logical lines: (1) Physiology; (2) relation to health; (3) meteorological factors of travel; (4) governmental control; and (5) prevention.

Temperature has quite an influence, due to volatilization of the odor elements, and humidity plays an important part; and those discussing the paper naturally mention wind movement as the important element in dissemination.

Professor Whipple calls attention to the fact that frequently odors are an indication of unwholesome conditions, but that unwholesome conditions must not always be thought to be absent when definite odors are not present—

* Discussion of the paper by Louis L. Tribus, M. Am. Soc. C. E., continued from December, 1921, *Proceedings*.

† Author's closure.

‡ Cons. Engr. (Tribus & Massa), New York City.

§ Received by the Secretary, March 14th, 1922.

|| *Proceedings*, Am. Soc. C. E., December, 1921, p. 733.

carbon-monoxide is virtually odorless, yet very deadly, and is given off in large quantities during the combustion of most fuels. Governmental control cannot well step in until nuisance exists or can be clearly anticipated; and such control then should be handled with great circumspection, yet as the writer suggested, and to which others have agreed, it might be secured in part by intelligent official advice, prior to the act.

Prevention is a field for intensive study, and is one that has occupied the attention of many a factory chemist, spurred in some instances by public sentiment and wrath, but often by the earnest desire of the plant management to do better things.

Dr. Gage tells of some interesting observations in attempts to control the offensive odors from certain oil refineries in Rhode Island, the presence of which was greatly desired as helpful industries, yet the operations of which were not the most agreeable. The fact was brought out that, in these cases, hydrogen sulphide and other sulphide gases were the chief offenders, the Mexican oil that was used containing more than 4% of sulphur.

It is difficult to realize the enormous quantities of these gases, certainly not helpful and highly odoriferous, that are given off daily in refining the much needed oil.

Mr. Osborn, out of his long experience in the study of the design, construction, and operation of garbage works, corrects the writer in certain references to garbage plants, and is probably justified in so doing. He devotes most of his discussion to the action of garbage reduction works and the causes of the dissemination of their odors, which he admits are offensive when not controlled.

The point which he emphasizes as of greatest importance, is not so much how far odors do or can travel, but how can they be prevented from traveling, a most pertinent conclusion.

Dr. Hering gives some physiological facts as to the perception of odors and their neutralization; that liquids make good carriers and that careful study makes possible almost complete elimination in cases of refuse disposal and sewage works.

Professor Landreth has given quite complete data on certain interstate litigation of prime importance, and New York legislation that has recently been helpful in abating certain undoubted nuisance cases, where odors of offensive character affected humanity and property at great distances.

Mr. Provost emphasizes some of the difficulties in the way of expert testimony and discusses certain specific types of offensive works, where publicity and, in some instances, drastic action, has secured the abatement of the nuisance, and also where a temporary nature has permitted operations, when permanence would have demanded cessation or change.

Mr. Weston discusses particularly the odors from sugar-house wastes, manufacture of lactic acid, and oil refining, and gives enlightening description of the processes and of testing apparatus designed especially to detect and standardize the odors given off, so as to make records that should be comparable and intelligible.

Mr. Potter contributes certain air-movement tests in sewers, looking to acquisition of knowledge as to the occurrence and behavior of sewer gases.

Mr. Saville rather looks forward to such scientific study, that curves and scales may yet be developed, that will enable far greater approximation of effects under standardized conditions, so that trained observers may even present data, that will be reasonably conclusive to the Court.

In general, it is agreed that a study of odors and their habits of travel would be of great economic service, and that on the engineer, devolves that duty.

The writer feels justified in having brought forward the topic, believing that, from it, more of helpful facts will be gathered and promulgated for the betterment of general living and, perhaps, the pocket-books of engineers.

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PAPERS AND DISCUSSIONS

RAINFALL AND RUN-OFF STUDIES

Discussion*

By C. E. Grunsky, M. Am. Soc. C. E.†

C. E. Grunsky,‡ M. Am. Soc. C. E. (by letter).§—The statements of Mr. Hinckley|| with regard to evaporation in parts of Oklahoma, should be taken with some allowance. Even in the hot, dry, almost rainless, and quite windy Salton Basin, California, the mean monthly temperatures of which are higher than those in Oklahoma, the annual evaporation from an open water surface is only about 6 ft. The writer would regard, as highly improbable, the evaporation of 10 ft., from an open water surface of any considerable depth and extent in 16 months, including 4 months of the contiguous years. This is also true of a rate of 2 in. per day for 15 to 20 days at a time. Such rates would obtain only from small experimental apparatus or from soil kept wet almost to the saturation point.

Possibly Mr. Jessup¶ is correct when he assumes that the greatest discharge of such a stream as the American River, California, will occur when a heavy rain falls on snow. The maximum melting effect will be due to a so-called warm rain; but the rain of maximum intensity is usually the cold rain which comes near the end of the storm. It will probably be found to be true that rain water plus water due to melting snow will never exceed the predicted maximum rain intensity for the entire water-shed. The checking of the suggested formula against any known results, where melting snow contributes to the peak discharge, is invited. If maximum rain intensities for the water-shed are properly determined and if topographic features have been properly considered in estimating the critical time, it is believed that the formula will be found to be dependable, even under the condition suggested by Mr. Jessup.

* Discussion of the paper by C. E. Grunsky, M. Am. Soc. C. E., continued from January, 1922, *Proceedings*.

† Author's closure.

‡ Cons. Engr., San Francisco, Cal.

§ Received by the Secretary, March 22d, 1922.

|| *Proceedings*, Am. Soc. C. E., January, 1922, p. 69.

¶ *Ibid*, p. 70.

The statement by Mr. Clarke* that the method of expanding short-time records to long-time records is applicable in the case of run-off as well as of rainfall, is true, but the data relating to measured run-off are accumulating slowly and in many parts of the United States the relative quantity of annual water production can only be determined for the long-time period from the rainfall records, which are generally available. He is correct when he states that the computed quantities of rain for any sub-station will frequently depart materially from the measured quantity. This can not be otherwise; but it does not detract from the value of the computed quantity (when no measured quantity is available) as an element for predicting what may be expected in the future. Furthermore, as stated by the writer,† there is less chance of agreement between any computed rainfall and the measured rainfall for a station, in regions such as the Atlantic Coast and the Middle West where thunder-storms, usually of small extent, occur. This, however, does not destroy the serviceability of the method as a basis for predictions of what may happen in the future. It must always be borne in mind that the purpose of studying rainfall and run-off of past years is to lay a foundation for the prediction of future probabilities. It can matter little, therefore, if predictions for individual seasons depart considerably from measurements. It is the possible sequence of seasons of various quantities of rain and run-off that is of consequence.

The writer is in accord with Mr. Wood‡ as to the value of the study of flow records where they are available for a sufficiently long series of years. They are particularly valuable for the streams in the Eastern United States, the range of discharge of which is much less than that of streams of the Pacific Coast. However, it will hardly do, as he suggests, to use the run-off records of streams from other regions as a basis for expanding a short-time Pacific Slope record. The first requisite, in such comparisons, must always be similarity of climatic and general topographic and geologic conditions.

The reasons given by Mr. Wood for adhering to the calendar year, in the matter of rainfall and run-off records, have little to commend them. The calendar year is good enough perhaps for the Southern Hemisphere where the New Year comes in a low-water period. It was a mistake to have adopted it for the Northern Hemisphere, and the mistake should not be perpetuated. The improved practice, for the reasons stated by the writer, should be adopted, but the division of the year that is intended and that should be adopted, should be the same for all parts of the United States.

The writer is particularly gratified to note that the U. S. Weather Bureau is giving careful consideration to the matter of revising the method of tabulating observations, as shown by the comments of Dr. Marvin,§ Chief of the Bureau, and some assurance has been given, by the Bureau, that in California the regular publications if not modified, will at least be supplemented with a special publication of the rainfall data in more useful form.

* *Proceedings*, Am. Soc. C. E., January, 1922, p. 71.

† *Ibid*, September, 1921, p. 203.

‡ *Ibid*, November, 1921, p. 561.

§ *Ibid*, Am. Soc. C. E., November, 1921, p. 566.

The discussions* of Messrs. Hering and Landreth are of interest but the writer does not wish to be understood as claiming that evaporation is the only factor that causes less water to run off than has fallen, as rain or snow, on any area. What is claimed is that evaporation is the predominating factor and that transpiration, the assimilation of water by growing plants, and evaporation, may be grouped together and for convenience called "evaporation". The causes making for reduced evaporation at high altitudes cited by Professor Landreth are offset in some measure by the fact that, at the high altitudes, snow remains long on the ground and there may be consequent replenishment of soil moisture long after the rain has ceased. It is not believed that any attempt to introduce other factors than temperature, which is the main index of the rate of evaporation, into the equation will meet with success and if the coefficient appearing in Equations (13) and (14)† has been determined for one or more water-sheds of any region, these equations should be found useful as written.

Mr. Horner's suggestion‡ that the value of the permeability factor, a, should not be constant for any density of population, will readily be conceded. The factor to use and how to vary it, must be left to the judgment of the engineer and the degree of approximation that is desired. The variability of this factor is recognized by the writer as shown in Equation (29), and the resulting Table 6.§ Mr. Horner suggests, too, that Table 6 has been extended too far. Experience alone will determine this on the basis of comparison of measured maximum discharge with the estimated discharge, when the facts relating to rainfall on the water-shed are sufficiently well known to make a comparison.

As an addition to the paper, it should be noted that, in using Equation (13) for run-off estimates, the mean temperature of no month should be entered at less than 32° in the calculation of the value of f. It should also have been stated that the coefficient, C, in Equation (14), is probably inversely proportional to n, the number of months, and that, consequently, Equation (13) is applicable regardless of whether the rain that produces the run-off, falls in 6 or 7 months, as on the Pacific Coast, or is more uniformly distributed to all the calendar months, as in other parts of the country.

* *Proceedings*, Am. Soc. C. E., November, 1921, pp. 566, 568.

† *Ibid*, September, 1921, p. 224.

‡ *Ibid*, January, 1922, p. 72.

§ *Ibid*, September, 1921, p. 233.

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THE RELATION BETWEEN DEFLECTIONS AND STRESSES IN ARCH DAMS

Discussion*

By Messrs. W. H. R. Nimmo, Gardner S. Williams and A. E. Greene, and F. A. Noetzli.†

W. H. R. Nimmo,‡ Assoc. M. Am. Soc. C. E. (by letter).§—The papers recently presented by Mr. Noetzli have brought out many interesting points bearing on the design of arch dams, and the solution of the circular arch under water loads by William Cain, M. Am. Soc. C. E.,|| is also a valuable contribution on the subject.

The writer recently had occasion to attempt the elastic analysis of the stresses in a proposed high arch dam, but arrived at the conclusion that the inaccuracies in the assumptions, which were necessary, rendered any numerical results valueless for the purpose of practical designing. For the same reasons, the writer is unable to accept the startling results arrived at by the author and, in the absence of definite evidence from observations, is not convinced that most arch dams are cracked.

Most investigators have adopted the method of equating the deflections of elementary horizontal arches and vertical cantilevers in order to find the proportions of water load carried by the two systems, the stresses in each system being then investigated separately. The method neglects other possible systems whereby part of the water load may be carried, but this probably causes an error on the side of safety and valuable results might be obtained if no other errors crept in. Unfortunately, the assumptions usually made, neglect, or do not accurately allow for, the following considerations:

(1).—Temperature variations, which are both uncertain in amount and irregular in distribution, the temperature in the body of the dam lagging be-

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* Discussion of the paper by F. A. Noetzli, Assoc. M. Am. Soc. C. E., continued from March, 1922, *Proceedings.*

† Author's closure.

‡ Asst. Civ. Engr., Hydro-Elec. Dept., Hobart, Tasmania.

§ Received by the Secretary, March 29th, 1922.

|| *Proceedings,* Am. Soc. C. E., October, 1921, p. 285.

hind the atmospheric temperature and this time lag is not the same at all levels in the dam.

(2).—Shrinkage due to setting of concrete.

(3).—Swelling due to soaking of concrete at the up-stream face.

(4).—Yielding of foundation due to eccentric vertical loading.

(5).—Yielding of foundation horizontally.

(6).—Yielding of abutments.

(7).—Deformation due to shear in cantilever.

(8).—Ordinary theory of flexure not strictly applicable to a triangular cantilever.

(9).—Cantilever assumed to be contained between parallel instead of radial planes. In a constant angle arch dam, the thickness at the lower levels becomes a large proportion of the radius, and this assumption involves considerable error in the value of the moment of inertia of the cantilever.

(10).—Formulas generally used for deflection of arch are not applicable when the arch thickness becomes appreciable in comparison with the radius.

(11).—Modulus of elasticity not the same for tension and compression.

(12).—Modulus of elasticity is not constant, but increases with the stress.

(13).—Effect of time factor in permitting increased deformation in the concrete.

(14).—Effect of lateral deformation.

(15).—Wedge action near base.

(16).—Possible arching in inclined planes.

Many of these points have been brought out in the previous discussion.

The effect of Assumptions 3, 4, 5, 7, 8, 9, 12, 13, and 14 would be to increase the deflection of the cantilever, and the combined effect may be sufficient to account for the differences in deflections as calculated by the author's method and as observed in existing arch dams.

By further complicating the calculations, it would be possible to develop a theory including the effects of Assumptions 7, 8, 9, 10, and 14, and the effects of yielding of foundation and abutments might be allowed for approximately. The effect of wedge action near the base and inclined arching, the writer believes, would be to relieve the horizontal arches and cantilevers, and a theory which neglects these, might still be of practical value.

The effects of Assumptions 1, 2, 3, 11, 12, and 13 are of prime importance and cannot be neglected, but, unfortunately, engineers are lamentably ignorant regarding them. Even if they could be accurately taken into account and the proportions of the load carried by the arches and cantilevers at the crown, at a given temperature, accurately determined, the difficulty would still remain, that these proportions would not hold for any other part of the dam, even at the same temperature. In reality, the load on the arches is not a uniformly distributed load, but an irregular one, which also varies with the temperature.

If an entirely satisfactory method of obtaining the stresses in an arch dam was available, it would be possible to design arch dams as reinforced concrete structures, which possibly would be more economical than dams of plain concrete. There is great need for more extensive observations on existing arch dams, including measurements of temperature, deflections, and strains,

supplemented by further laboratory tests on concrete mixtures in regard to their elastic properties. When sufficient data of this kind are available, reliable formulas for the more economical design of arch dams may be developed. In the present state of the knowledge, it is probable that responsible engineers will continue to design arch dams on the assumption that the arches carry all the load, and it is for the purpose of more nearly realizing this condition that the system of grouting joints under pressure has been introduced.

The principal objection to the pressure grouting of joints arises from a belief that uneven filling of the joints will cause eccentricity of the arch thrust, which will result in dangerous bending moments. Although it is not probable that the grouting of joints can be made 100% efficient, it should be possible, with sufficiently close spacing of the grout pipes, to insure that such air pockets as might remain, would be small and well distributed over the cross-section, in which case, no appreciable eccentricity of the thrust would be caused. A small increase in the intensity of the arch thrust at the joint might result, but this would not be serious, and it is likely to arise even if the joints are not grouted, from débris falling into the joints while they are open. In a dam, the joints of which open and close periodically, the effect of varying temperatures in the lower arches, combined with the resistance of the cantilevers, will cause the upper arches to close on slightly varying alignments, unless they are accurately keyed at the joints. In other words, the keys will be carrying shear stresses before the joints in the upper part of the dam have closed, which means that the surfaces of the keys may be sliding against each other under pressure, and this is certainly not a desirable condition. If satisfactorily carried out, there can be little doubt about the advantages of grouting joints under pressure.

In dealing with the deflections of the Salmon Creek Dam, the author finds, by subtracting the deflection at Elevation 1095 from the mean of the deflections at Elevations 1075 and 1115, that the cantilever has suffered a deflection of 0.18 in. in a length of 40 ft. The method of measuring the deflections has not been described in detail, but if they were made by angular measurements with an ordinary transit instrument, reading to, say, 10″ of arc, they may easily be in error by ± 0.05 in., in which case the 0.18 in. previously mentioned, may be greatly in error.

Gardner S. Williams,* M. Am. Soc. C. E., and Albert E. Greene, Esq.† (by letter)‡.—At the time Mr. Noetzli's interesting paper was published, the writers were engaged in designing an arch dam about 85 ft. high and of 325 ft. radius. The available literature on the subject had been studied, various designs of thin arch dams had been examined, and the conclusion had been reached that the usual method of designing by the formula, $T = P\,R$, was not even approximately correct and that all existing thin arch dams of considerable span that are not anchored to the rock by reinforcing, must have opened a horizontal joint at the base. The deflection measurements of the Barren Jack and the Salmon Creek Dams seem to prove the failure at the base, beyond

* Cons. Engr., Ann Arbor, Mich.

† Ann Arbor, Mich.

‡ Received by the Secretary, April 1st, 1922.

question. As it was not desirable to attempt to fix the base of the proposed dam, it was decided to make a hinged joint there and to allow the dam to rock freely with the imposition of the water load and, particularly, under changes of temperature. The site is in a gorge with a level bottom, and the arch dam is sprung between vertical abutments at the side-walls. For this particular condition, the stresses in a dam of any chosen cross-section can be computed readily.

The dam is assumed to consist of a system of vertical needles supported by a system of horizontal arch ribs, as shown in Fig 13, the assumption made by every one who has attempted a solution of the problem, as far as the writers are aware. Because of the long radius and the consequent thickness of the dam, the needles of the design in question are much more rigid than the arch ribs and remain practically straight, transmitting excesses of pressure from one arch to another when the arches deflect under load. The deflection of any rib, therefore, is proportional to its distance above the hinge at the base and, as the unit stress in any rib is proportional to the deflection of that rib, the unit stress at any point of the cross-section is proportional to the distance of that point above the hinge; that is, the thrust in the arch dam is distributed over the section in the same manner as the stress is distributed, under positive bending moment, over that part of the section of a beam lying above the neutral axis.

FIG. 13.

To find the magnitude of the rib stresses consider the equilibrium of one of the needles lying between two radial planes, 1 ft. apart, at the up-stream face of the dam where the radius is R. The needle is in equilibrium under the action of the water pressure, its own weight, the reaction of the arch ribs, and the reaction at the base. The two sides of the needle are cross-sections of the dam and are inclined to each other at an angle of $\frac{l}{R}$, and it is on these sides that the arch thrusts are actually applied, as shown in Fig. 14, and not on the face, as shown in Fig. 13. Let f be the normal unit stress on the cross-section at an elevation, y, above the base, and let f_c be its value at the crest. The component of f on the median plane of the needle, therefore, is $\frac{f}{R}$, and on any elementary area of the cross-section $d\ A$ distant y above the base, there is a force of $\left(\frac{f}{R}\right) d\ A$ opposing the water pressure. Taking moments about the lower end of the needle or the base of the dam and equating the overturning moment of the external forces to the resisting moment of the components of the rib stresses in a manner similar to that followed in deriving the expression for the moment of resistance of a beam, since $f : y = f_c : h$, we have,

$$M = \int_0^h \frac{f}{R}\, y\, d\ A = \frac{f_c}{R\, h} \int_0^h y^2\, d\ A = \frac{f_c\, I}{R\, h}$$

or, the arch stress at the crest is,

$$f_c = \frac{M\,h\,R}{I}$$

in which I is the moment of inertia of the vertical cross-section of the dam about an horizontal axis at the base, and M is the moment of the external forces, the water pressure, and the weight of the structure, acting on a vertical slice of the dam 1 ft. wide at the up-stream face.

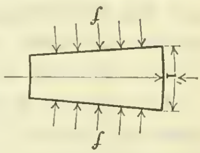

FIG. 14.

It appears that the most economical section for a dam of this type is one with a large value of I and that, instead of making the crest narrow and increasing the thickness toward the base where the arch stress is zero, good designing will place as much material as possible near the crest. A wall of uniform thickness, therefore, is preferable to the usual trapezoidal section for dams of moderate height in a box canyon.

Attention must be given to the design of the needles which, if of the usual form, will require reinforcing on the down-stream face to prevent breaking. The line of thrust can be kept within the cross-section and the necessity of reinforcing obviated by curving the structure in the vertical plane, as one of the writers did in the Six-Mile Creek Dam.* Where reinforcement has been used in the past, the arches have been reinforced and not the needles which particularly need it, if the dam is to act as a monolith.

Temperature stresses in dams of this type were found to be of much importance, and they are undoubtedly so in all arch dams. In the design in question, it was computed that a change in the temperature of the concrete of 30° Fahr. would deflect the crest about twice as much as the water pressure alone, so that, assuming the dam to be built with expansion joints, which are to be filled in cold weather, the dam might be expected to deflect up stream in the summer with full pond, as far as it would deflect down stream in winter, both deflections being measured from the unstressed position.

The formulas developed for this dam placed between two vertical abutments should not be applied to thin arch dams in a valley with sloping sides. Writers who have attempted an analysis of the general problem have assumed that every arch rib carried a uniform radial load. As the water pressure on any rib may be carried in part by that rib and may be distributed in part by the needles to other ribs, there is no good reason for thinking that a given rib is uniformly loaded, except in the case where all the needles are of the same length.

An attempt was made to analyze the two dams the deflections of which are discussed by the author, on this basis, and it appeared that the needles were not strong enough to distribute the water loads between the various ribs. It is believed that the upper arches of a dam in a V-shaped valley are relieved of part of the load and this would be indicated by their deflections if the assumption previously mentioned was correct, because they do not take the form the computer thinks they should. For this reason, the writers do not wholly agree with the author in his conclusions about computing the stresses

* *Transactions*, Am. Soc. C. E., Vol. LIII (1904), p. 183 *et seq.*

from the deflections. They, however, would congratulate him on this and his previous paper,* which are valuable additions to the progress being made in the analysis of arch dams.

While on the subject of arch dams the writers would place on record some unusual examples, which do not appear in any of the published lists they have seen. These dams are timber structures now or formerly existing on Taghanic and Six-Mile Creeks, near Ithaca, N. Y., where the geological formation consists of shale in horizontal layers with vertical fracture joints, which affords a channel with a level bottom and nearly vertical sides.

The first of these structures is the Van Natta Mill Dam on the Six-Mile Creek, at Ithaca, N. Y., which property was acquired by the Ithaca Water-Works Company in 1892. Previous to that, it had been used as a grist-mill and the dam had been in place for many years. The date of its construction is unknown to the writers. It continued in service until the great flood of June, 1905, when with a head between 7 and 10 ft. above its crest, it was carried away.

The dam which rested on rock, consisted of a spillway between two masonry abutments. The spillway was 2.35 ft. thick, built of planks laid flat and spiked together and was anchored to the rock by iron rods about 10 ft. apart, extending several feet into the body of the work. The length of the crest of the spillway, on center line, was 90.25 ft., with a down-stream chord length of 86.4 ft. The north abutment was from 4 to 6 ft. thick, whereas that at the south was about 2.5 ft. thick and extended in a curve about 16 ft. to a vertical rock face against which it abutted, its height varying from 3 to 7 ft., of which 2 ft. was above the crest of the spillway. The up-stream radius was 100.66 ft. The crest of the spillway was inclined, the down-stream edge being 9 in. higher than the up-stream corner. For 56 ft. of its length, the spillway was from 17 to 18 ft. in height, and in the 16 ft. next the north abutment, the rock was inclined so as to give it a height of 12 ft. at that abutment. On the south, the rock inclined through the last 18 ft. giving a height of spillway at the abutment of only 5 ft. At the time of failure, the flow in the creek was more than 8 000 cu. ft. per sec., and the structure had withstood previous floods of more than half that quantity.

The second dam was built by the Ithaca Water Company in Six-Mile Creek about 600 ft. down stream from the so-called Six-Mile Creek Dam, and varied in height from 5.6 to 6.5 ft., had an up-stream radius of 109 ft. and a span of 94 ft., with an uniform thickness of 1.42 ft. It was built of two walls of 2 by 4-in. timbers, laid flat, with the intervening 9-in. space filled with concrete. It was anchored to the rock with rods about every 5 ft. This dam, which was in the gorge,† was in service four or five years and passed floods of 2 to 4 ft. over its crest. During the construction of the Six-Mile Creek Dam, about one-third of it was removed to drain the gorge and was later replaced. It was tipped over at the center and partly carried away in the flood of 1905, which passed over the dam above, with a head of about 10 ft. It is not known at what time during the flood this dam failed. The discharge of the creek

* "Gravity and Arch Action in Curved Dams", *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 1.

† *Transactions*, Am. Soc. C. E., Vol. LIII (1904), Plates IX and X, pp. 184, 186.

during the flood was at the rate of more than 8 000 cu. ft. per sec., and this dam had withstood a flood of about 4 000 cu. ft. per sec., previously.

In 1904, one of the writers built the third dam which is across Taghanic Creek above Taughannock Falls and may be seen from the Lehigh Valley Railroad. The up-stream radius is 120.5 ft., the span 150 ft., the height is approximately 6 ft. throughout its length, and the thickness is 1 ft. It is built of oak plank laid flat and spiked together, and anchored to the rock by 1-in. bolts every 4 ft. Each alternate bolt goes to the crest, the others going through the sill only. They are set 1 ft. deep into the rock.

During a heavy flood in March, 1912, ice was brought down the creek in blocks 2 ft. thick and more, and lodged against the dam, and the head-water rose to a height of 5 or 6 ft. above the crest. The accumulated ice and water folded the dam over at its center, until the upper part of the section lay almost at right angles with the lower part. When the flood subsided, the deformed part was jacked back into position, a timber brace was set against its center and the structure continued in service.

Another structure, which may be of interest in this connection, is Campbell's Dam in Cascadilla Creek at Ithaca, designed by one of the writers and built by the owners in 1904. It is of concrete, reinforced with miscellaneous iron and steel rods. The up-stream radius is approximately 70 ft., the crest is 29 in., and the base 4 ft. thick. The up-stream face inclines down stream 1 in. per ft. The length of the crest is 51.6 ft. at the down-stream edge. The abutments, which are part of the arch and about 3 ft. above the crest, are 25 ft., and 11.3 ft. long at the crest level. For 35 ft. of its length, the dam is 25 ft. in height and decreases to 17 ft. at the south abutment, and runs to zero at the ends. This dam has had a flood of about 5-ft. head over it.

The Van Natta, Taughannock, and Campbell Dams were all near the crest of a fall, so that the back-water could not rise more than 2 or 3 ft. below, in any case. The dam of the Ithaca Water Company was undoubtedly submerged in the big flood.

F. A. Noetzli,* Assoc. M. Am. Soc. C. E. (by letter).†—By a fortunate coincidence, the writer's investigations on arch deflections and stresses were published‡ at the same time as a paper on a similar subject by William Cain, M. Am. Soc. C. E. The writer concentrated his efforts on the development of simple methods and approximate formulas that might be more easily understood and used by hydraulic engineers engaged in dam design, whereas Professor Cain has effected, in a brilliant manner, the theoretically correct solution of the determination of the stresses in the arching parts of arch dams. A comparison between the two methods discloses the fact that in many cases results obtained by the writer's approximate formulas are almost identical with those obtained by the exact method of Professor Cain. In other cases, some discrepancy exists, as was naturally to be expected. However, the difference for true arches, within practical limits, is seldom great enough, that it could not be considered practically negligible when compared with the uncertainties involved in

* Chf. Engr., Beckman & Linden, Eng. Corporation, San Francisco, Calif.

† Received by the Secretary, March 4th, 1922.

‡ *Proceedings*, Am. Soc. C. E., October, 1921.

the assumptions as to the modulus of elasticity, degree of shrinkage of concrete, range of temperature, etc. The greatest discrepancy is found where the two methods are applied to thick and flat arches such as generally occur in the lowest parts of arch dams. It is questionable, however, whether any known arch formula can be applied to very thick arches without considerable modification. Professor Cain has shown, for instance, in an arch 40 ft. thick, of 135 ft. radius, and with a central angle of 40°, that only about 2½% of the radial load is supported by what is commonly understood as arch action. In his discussion* of Professor Cain's paper referred to previously, Mr. Mensch has indicated why such an "arch" cannot act as a horizontal beam, and the writer has tried to illustrate the reasons why "secondary arch action" within the arch may interfere with true arching.†

In any arch for which it is possible to inscribe, for instance, another arch of half the thickness and having a radius of less than half the radius of the primary arch, so-called secondary arch action is likely to occur. The reason for this lies in the fact that the stresses in the secondary arch are theoretically less than those in the primary arch for the same load, and Nature makes use of this fact by what is known as the "principle of least work". Not only one secondary arch is formed within the body of the primary arch, but a series of elementary arches, whereby the load can be supported with a minimum of elastic deformations according to the previously mentioned "principle of least work."

Furthermore, an investigation made by the method of combined cantilever and arch action will generally show that, in the lower parts of dams, arch action is very small, most of the load near the foundation being supported by the vertical cantilevers. These considerations unquestionably argue for caution in applying any kind of arch formula to the lowest parts of arch dams, and if such extreme cases are excluded, it will be found that the writer's approximate formulas given in his paper may well be used to illustrate the relation between deflections and stresses in arch dams.

In order to avoid misunderstandings, it may be desirable to fix some limits outside of which the approximate formulas cannot be expected to furnish other than rough approximations. In the writer's judgment, the deflection stress Formulas (1) to (9) should not be applied without modification to such arches for which the proportion between thickness and rise of arch is nearly unity or even larger, that is, for which, say, $\frac{t}{h} \geqq 0.8$. It is admitted that the coefficients, k, taken from the curves of Fig. 4, furnish somewhat too large stresses, particularly for arches with central angles of more than 100 to 120 degrees. Those coefficients become more nearly correct by reducing them by the proportion between length and span of the arch.

Mr. Mensch‡ raises the interesting question of why an arch dam, in which according to the writer's theory the cantilever appears to have developed cracks, does not leak. Leakage is prevented by the weight of the masonry. Although

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 795.

† *Ibid*, March, 1922, p. 684.

‡ *Ibid*, December, 1921, p. 791.

a dam may have failed in gravity action and developed horizontal cracks at the up-stream face, the concrete near the down-stream side is under high compression. Therefore, cracks, due to bending of the cantilever, will hardly ever extend through the dam for this same reason. The conditions are different for circular reinforced tanks for which the vertical walls have not been tied adequately to the base to take care of the vertical bending moment. In such faultily designed tanks, the bending moment at the base of the thin and light vertical walls generally starts a crack, and uplift and shear do the rest, thus effecting a measurable movement between vertical walls and base, and leakage is almost certain to occur. In dams which may be from 30 to 40 ft. thick at the base and which are prevented from considerable movements by the relatively close vicinity of the side abutments, there is little chance for a crack to extend all the way through, as the weight of the masonry above will always tend to close a crack and seal tightly the down-stream part.

Mr. Mensch further asks why an arch, which according to the writer's approximate method ought to show serious defects, does not fail? It may be stated that the example to which Mr. Mensch makes particular reference is a rather extreme case,* that is, an "arch" for which the thickness is about 1.3 times the rise $\left(\frac{t}{h} = 1.29\right)$. Furthermore, it is to be considered that any formula, if applied to a hingeless, unreinforced concrete arch, gives reliable results only if the arch has no open cracks. If calculations show that excessive tension occurs in such an arch at certain places, so that cracks may be expected on the tension side, such cracks act statically as a kind of "hinge" and the basic assumptions for a hingeless arch are void and, therefore, also the formulas based on such assumptions. If a crack (partial hinge) which, for instance, may have opened due to a rise of the arch temperature when the reservoir was empty, is closed entirely by the pressure of the rising water, the arches may again be considered as hingeless for purposes of stress calculations, although, of course, the crack still exists.

To make this point clear, assume an arch dam with reservoir empty, and such a decrease of temperature that the construction joints have opened. Either Professor Cain's exact formula for temperature stresses, or the writer's approximate formula, or any other formula, would furnish, for such a decrease of the arch temperature, certain stresses at the abutments as well as at the crown of the dam. As the construction joints are open, it is evident that no stresses can be transmitted through such open cracks, and both the crown and abutments of the arches may be without temperature stresses. However, due to the shortening of the arch sections resulting from the assumed drop of temperature, the two surfaces of each joint are turned in such a manner that they are no longer parallel. If the water rises and presses against the arches, the temperature being the same, the open joints will begin to bear unevenly against each other. For instance, at the crown, the parts farther up-stream may start to transmit the arch thrust from water pressure, while the joint may still

* Such conditions were referred to by the writer in "Gravity and Arch Action in Curved Dams", *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 134, to be examined by the exact theory of the elastic arch.

be slightly open on the down-stream side. Eventually, the water pressure may be sufficient to produce compression over all the sections of the arch, and therewith the conditions for theoretical hingeless arch action are re-established, and the formulas apply for this condition, although the arch is cracked.

Furthermore, it may happen that, in a solid unreinforced arch, the thrust has moved outside the middle third of the section and sometimes, theoretically, even outside the section itself. As soon as the tension produced by the eccentricity of the arch thrust is large enough to open a crack on the tension side, an artificial "hinge" is created and the arch thrust is automatically moved back, and passes through the center of the "hinge". The assumptions as to hingeless arch, therefore, are changed for these conditions and the results from the formulas have to be interpreted accordingly.

Such considerations may clear some misunderstandings that certain members seem to have had from applying the formulas and conclusions of the writer with respect to the present conditions of certain arch dams. For arches that are adequately reinforced, the formulas apply within their limits of accuracy, without modification.

Professor Cain's numerical examples, by using his exact method and comparing the results with those obtained by the writer's approximate formulas, should prove instructive. Thus, the similarity of the results of respective calculations applied to the arch slice at Elevation 1115 of the Salmon Creek Dam is rather striking. The stresses at the crown were found to be:

	Cain.	Noetzli.
At the extrados, $f_c =$	468	461 lb. per sq. in. (compression)
At the intrados, $f_c =$	126	94 lb. per sq. in. (compression)

and at the abutments,

At the intrados, $f_c =$	656	645 lb. per sq. in. (compression)
At the extrados, $f_c =$	— 22	— 89 lb. per sq. in. (tension)

The difference between the two results appears to be slight if compared with the results obtained by the cylinder formula which furnishes, both at the crown and at the abutments, a uniform axial stress of 307 lb. per sq. in. (compression).

The point that the writer desired to bring out by the determination of the stresses from measured deflections was particularly to show the wide discrepancy between cylinder theory and actual conditions. It is immaterial, therefore, whether the results by the approximate formulas differ a few pounds per square inch from the theoretically correct values, as long as the apparent defects of existing arch dams may be brought, in an easily comprehensible manner, to the attention of engineers. In order to obtain more nearly correct results by the writer's method, it would be necessary to determine the actual load on the arch by the method of combined cantilever and arch action. For illustrative purposes, however, the figures given may be considered as sufficiently accurate to arouse the interest of engineers in arch deflection stresses.

The writer is unable to agree with Professor Cain's interpretation of the part played by temperature deformations, if the stresses in an arch ring are to be determined from the deflections. The formula for the deflection, *D*, on page 80,* seems to be incorrect as far as the part referring to temperature is

* *Proceedings*, Am. Soc. C. E., January, 1922.

concerned. This is evident from Fig. 18 (*a*) and Fig. 18 (*b*)* from which this formula was derived. It also differs considerably in its results from Professor Cain's exact formula for temperature deflections.

Furthermore, the writer questions whether the assumption of "dam simply supported at the base, with no bending moment there", will ever be valid in the case of high dams. Such a dam may have developed cracks and, therefore, a partial "hinge" near the center of the canyon, but such cracks hardly ever will extend all along the side abutments. Therefore, bending moments at the base are certain to exist in the vertical cantilevers nearer to the side-hills. Furthermore, the weight of the masonry of high dams will always exert a considerable moment at the base, which acts in an opposite direction to the moment produced by water pressure. The deflections of an arch are influenced materially, also, by the moment exerted by the weight of the dam and the neglect of this weight moment, made by the assumption of "no bending moment at the base", may lead to results more or less in error.

Professor Cain's theoretically exact deflection Formula (15)† for which coefficients were given in Table 1‡ will be of great help in many cases. As a matter of comparison those coefficients were plotted in Fig. 15 together with the coefficients, 1.56, and $\frac{3L^2}{16h}$, of the writer's approximate deflection formulas.

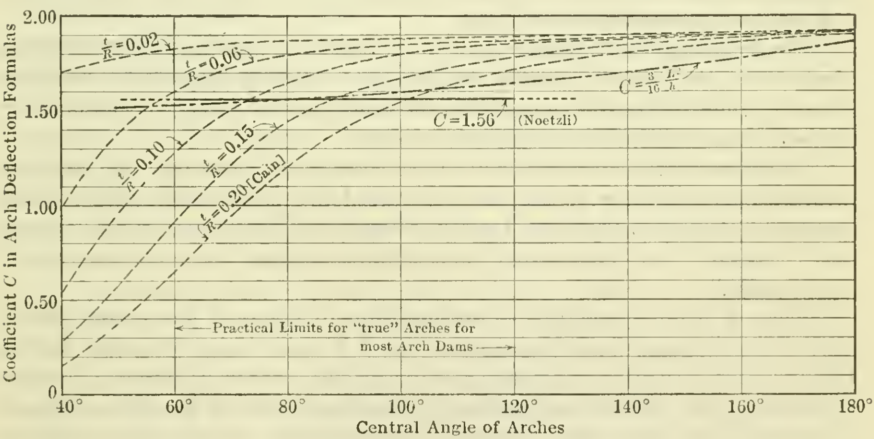

FIG. 15.

It will be noticed that the difference is comparatively small for most arches of the upper parts of arch dams where free arching may occur. In cases where accuracy is of great importance, Professor Cain's exact coefficients should be used for calculating deflections, in preference to the writer's approximate formula. In the writer's opinion, both formulas should be applied with caution for very thick or flat arches.

* *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 80.

† *Proceedings*, Am. Soc. C. E., October, 1921, p. 293.

‡ *Ibid*, p. 286.

The writer fully appreciates the excellent results arrived at by Professor Cain in his admirable paper on "The Circular Arch under Normal Loads".* Engineers who desire to design arch dams with the utmost degree of accuracy, will find satisfaction in Professor Cain's formulas. Hydraulic engineers who prefer simple formulas, simply arrived at, may be satisfied to use the writer's approximate theory of arch dams. Occasional check calculations for critical cases, for instance, when the stresses, calculated by the approximate method, appear to be near the permissible limits, may be made by the exact theory and without unduly lengthening the procedure.

The writer is unable to appreciate the efforts of Mr. Jakobsen† in calculating the influence of shear on the deflections of the Salmon Creek Dam. In calculating the angle at the base of the dam, Mr. Jakobsen assumes the cantilever as carrying all the load for the full height of the dam, and the arches nothing, whereas apparently the opposite is more nearly correct in this particular case. Therefore, Mr. Jakobsen's results are evidently greatly in error.

In the second example, relating to the short cantilever below Elevation 1035, Mr. Jakobsen apparently overlooked the fact that the writer gave the value, 20 000 000 lb., only for the purpose of illustrating the impossibility of such a cantilever deflecting "elastically" the amount measured. The total water pressure on the 28-ft. cantilever is little more than 250 000 lb., or only about 1% of the load assumed by Mr. Jakobsen. His calculated shear deflection, therefore, is nearly one hundred times too large.

In calculating the probable size of the crack at the base of the Salmon Creek Dam, Mr. Jakobsen makes the assumption that the cantilever stands on its edge, which is absurd, considering the fact that the weight of the masonry above is nearly 700 000 lb. per lin. ft. of dam.

The writer is also unable to follow Mr. Jakobsen's reasoning, that an unreinforced concrete beam of the size considered in his example and for which standard calculations indicate tensile stresses of 2 750 lb. per sq. in., should not be cracked, but "shows that the ordinary bending formulas are entirely inapplicable."

There is little probability of seeing, from a distance, the cracks on the warped down-stream face of the Salmon Creek Dam, at either Elevation 1075 or Elevation 1155, and this may be the reason why such cracks, apparently have not been discovered. At the upper elevation, the dam is only 11 ft. thick, and there is no reason to assume that a beam of this thickness should act so greatly at variance with theory, as Mr. Jakobsen would have one to believe. The fact that apparently no one has seen those cracks is not conclusive proof of their non-existence, and if standard calculations show, theoretically, tension stresses 10 to 20 times larger than average concrete is known to be able to stand without breaking, the conclusion as to the occurrence of cracks would appear to be well justified.

Mr. Dunn‡ deserves much credit for having called attention in such an able manner to the probability of uneven loading of the horizontal arches at certain dam sites. In fact, the writer has had the same experience in similar

* *Proceedings*, Am. Soc. C. E., October, 1921, p. 285.

† *Ibid*, January, 1922, p. 85.

‡ *Ibid*, January, 1922, p. 88.

cases, and for this reason has suggested* that "in addition to the foregoing investigation of the cross-section of the dam near the arch crowns, in general it will be desirable to investigate also the sections at about the quarter points [or any other points] of the highest arches, * * *." The writer has come to the conclusion that in all cases for which the difference of the arch load at the crown and near the abutments is not very large, the maximum load may be assumed as acting uniformly over the whole arch. Rib-shortening and shrinkage have the tendency to move the arch thrust at the abutments toward the air side of the arch, thus approaching again more closely the circular form of arch axis. However, every dam site has its own peculiarities and no definite rules can be stated.

Mr. Miller's† excellent presentation of the derivation of exact formulas for secondary arch stresses is noteworthy, and his curves which show the over-estimate of the value of the deformation thrust, H, for the various approximations, will be of good service to designers. Thus, it is possible to judge from those curves whether, for an arch of given dimensions, the error involved by the use of an approximate formula is large enough to warrant the application of a more accurate one; or one may use the approximate formulas and deduct the percentage of error, according to Mr. Miller's curves, to arrive at the exact values.

Mr. Hill‡ questions whether the writer's formulas for cantilever deflections are strictly applicable to dams. Any theory applied to an unreinforced concrete structure which has developed cracks, is naturally more or less unreliable for such a state of deformation, because the statical conditions of the structure may have changed considerably at the instant that cracks occurred. If the formulas indicate excessive tension, and, therefore, the probability of cracks, it is not to be wondered if the actual deflections are out of all proportion to what pure theory would show them to be. It is hard to imagine a thick dam as simply supported ("hinged") without rather complex conditions resulting at the base from large deflections.

It has been claimed by some engineers that the usual methods of calculating the deflections and stresses in cantilevers do not apply to the vertical cantilever slices of arch dams. For thin and comparatively low dams, there is no reason why the standard methods of structural design should not be applicable with the same degree of accuracy as in building or bridge construction. For instance, the Barren Jack Dam is only 5 ft. thick at the base and 2 ft. thick at the crest, and the concrete is probably of the same quality as that in other structures, so that the same assumptions and laws may be applied. It is possible, however, that, for very high and thick dams, the usual assumptions as to Hooke's law, modulus of elasticity, etc., may have to be modified somewhat. The question is, how far and for what size of dam are such new rules to be applied. This can only be determined by tests.

Some engineers also rely, to a great extent, on the "flow" of concrete under high compression, and on the "time factor". The writer would suggest caution

* "Gravity and Arch Action in Curved Dams", *Transactions*, Am. Soc. C. E., Vol. LXXXIV (1921), p. 25.

† *Proceedings*, Am. Soc. C. E., March, 1922, p. 676.

‡ *Ibid*, February, 1922, p. 359.

in applying such assumptions indiscriminately and before definite rules have been established by tests on dams. In the present state of knowledge, it would appear to be safer practice to calculate the stresses in arch dams according to the well established theories and assumptions used in the design of other concrete structures, and then make, if desired, a correction for flow, time factor, etc., of 10, 20, or 50%, or whatever may be judged to be reasonable for the particular structure in question.

Cantilever and arch deflection stresses of considerable magnitude are likely to occur in any arch dam, and such stresses should be taken care of, in addition to those resulting from pure cylinder action. In no case should designers of arch dams continue to imitate the ostrich which is said to bury its head in the sand in the endeavor to hide from a threatening danger.

One of the main purposes of the writer's recent papers was to arouse among hydraulic engineers more general interest with regard to true arch action in arch dams. Instead of following strictly theoretical lines, as others had done, he chose to simplify the various problems encountered by developing approximate methods and formulas that might be more easily understood and more readily applied, without the necessity of delving into all the intricacies of the theory of the elastic arch. Several exact methods of designing arches according to scientific principles were developed a score or more years ago. One of the main reasons why such methods have not been used more generally for arch dams is their complicated form which makes it difficult for the average engineer to study and apply these methods in the usual short time allowed for the design of dams. The writer hopes, therefore, that his approximate formulas may be of help to engineers as an intermediate step on the ladder to perfection.

Other cases are known in structural design where approximations are used extensively for the sake of simplicity. The most striking example is the present standard design of continuous girders, for which the coefficients of $\frac{1}{8}$, $\frac{1}{10}$, and $\frac{1}{12}$ are used for calculating the bending moments, instead of the theoretically more exact but much more complicated "three-moment equation" by Clapeyron. Engineers versed in structural design are well aware that the difference between the approximate and the theoretical results is often 50% and more, particularly in the case of heavy live load on continuous girders of uneven spans. However, the approximate formulas are almost universally in use, on account of their simplicity.

In conclusion, the writer wishes to emphasize again the desirability of taking deflection and temperature measurements on arch dams. In order to obtain results within a reasonable time, it is suggested that the Society invite every member who may be able to secure such data, to submit them for publication and discussion. In order to make the results obtained from the measurements at various dams more easily comparable with each other, and thus enable conclusions to be drawn covering a great variety of conditions, a similar program with regard to the measurement of deflections as well as of the temperature of air and water should be adopted by all observers.

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PAPERS AND DISCUSSIONS

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THE FLOOD OF SEPTEMBER, 1921, AT SAN ANTONIO, TEXAS

Discussion*

By Messrs. C. E. Ellsworth and C. Terrell Bartlett.†

C. E. Ellsworth,‡ Assoc. M. Am. Soc. C. E. (by letter).§ The author is to be commended for his initiative and promptness in collecting much valuable data regarding the San Antonio flood and for his service to the Profession in making such data available.

The writer has prepared this discussion for two purposes:

1.—To make available in printed form, in advance of official publication, the records of stage and discharge of San Antonio River, that are on file in the office of the U. S. Geological Survey and the State Board of Water Engineers at Austin, Tex.

2.—To prevent the impression that a reasonably accurate rating and determination of discharge during the flood could not be made, because the water-stage register, referred to by the author, was located at the South Alamo Street Bridge, which failed.

In discussing the accuracy with which the discharge could be determined, the writer is unable to recall the exact statements he made to the author at different times, immediately after the flood, but he was then of the opinion and probably conveyed the idea that the rating was less accurate than the final analysis indicates.

Like practically all such determinations during great floods, the calculations of maximum discharge and run-off are liable to considerable error. The writer believes, however, that the accuracy with which this flood has been measured is relatively high, because a practically complete graph record of stage was obtained and because the stretch of channel a short distance down stream from the gauge was relatively favorable for the determination of peak

* Discussion of the paper by C. Terrell Bartlett, M. Am. Soc. C. E., continued from March, 1922, *Proceedings*.

† Author's closure.

‡ Dist. Engr., U. S. Geological Survey, Austin, Tex.

§ Received by the Secretary, March 21st, 1922.

discharge by the slope method. Sufficient current-meter measurements of discharge are available for the low and the medium stages, so that no gross errors are possible in the rating. (See Table 1.)

TABLE 1.—List of Discharge Measurements of San Antonio River, at San Antonio, Tex.*

Number of measurement.	Date.	Gauge height, in feet.	Discharge, in second-feet.	Method.	Location.
81	March 11, 1921	2.51	391	Current-meter	At gauge
87	Sept. 8, "	1.38	76	"	"
88	Sept. 9, "	3.31	622	"	"
89	Sept. 10, " †	20.14	15 300	Slope	2 000 ft. below gauge
90	Sept. 10, "	8.94	2 200	Current-meter	Nueva Street Bridge 1.3 miles above gauge
91	Sept. 10, "	5.57	866	"	Railroad bridge 400 ft. above gauge
92	Sept. 21, "	3.13	153	"	At gauge
93	Oct. 4, "	2.90	117	"	"

*Numerous discharge measurements, not listed, have been made at stages less than 2.00 ft.
†Measurements of cross-section and slope were made on September 15th to 17th, 1921.

The author has stated that:

"It is unfortunate that the water-stage register of the Geological Survey was located at the South Alamo Street concrete bridge which failed. Although the gauge itself was undamaged and recorded the levels, except for 3 hours at the crest, the failure of the bridge interfered with the channel, so that no accurate rating curve can be established for the flood conditions."

The water-stage register was installed in April, 1920, by the Engineering Department of the City of San Antonio, according to a plan prepared by the Water Resources Branch of the U. S. Geological Survey which maintains a District Office at Austin in co-operation with the State Board of Water Engineers. The site, at the down-stream side of the right abutment of the South Alamo Street Bridge (Fig. 5*), was selected by Hans Helland, M. Am. Soc. C. E., then City Engineer, and the writer, after a thorough examination of the course of the river through the city and a careful consideration of all conditions that might affect the accuracy of gauge records and the determination of discharge. The writer is now more firmly convinced than ever that a better record of the flood could not have been obtained at any other location, except, possibly, farther down stream, in the vicinity of the section used for the determination of discharge by the slope method. The use of that section, however, is dangerous owing to the possibility of back-water from San Pedro Creek and from débris that is likely to collect at the crossing of the Missouri, Kansas and Texas Railroad Bridge. A study of the overflowed area and of the condition of the channel, due to obstructions caused by débris collected at bridge piers and other constricted sections, shows that the relation between stage and discharge at any section above the South Alamo Street Bridge would have been decidedly uncertain at any time during the flood, and that the flow of water below the gauge was relatively unobstructed and permanent.

* *Proceedings*, Am. Soc. C. E., November, 1921, p. 447.

Even after the bridge had failed and partly collapsed, the channel capacity was not reduced as much as it was at many other bridges which did not fail, but at which greater quantities of débris were collected. Practically, the only effect the failure of the bridge had on the rating, was caused by a few small blocks of concrete, which broke loose and lodged in the channel below the

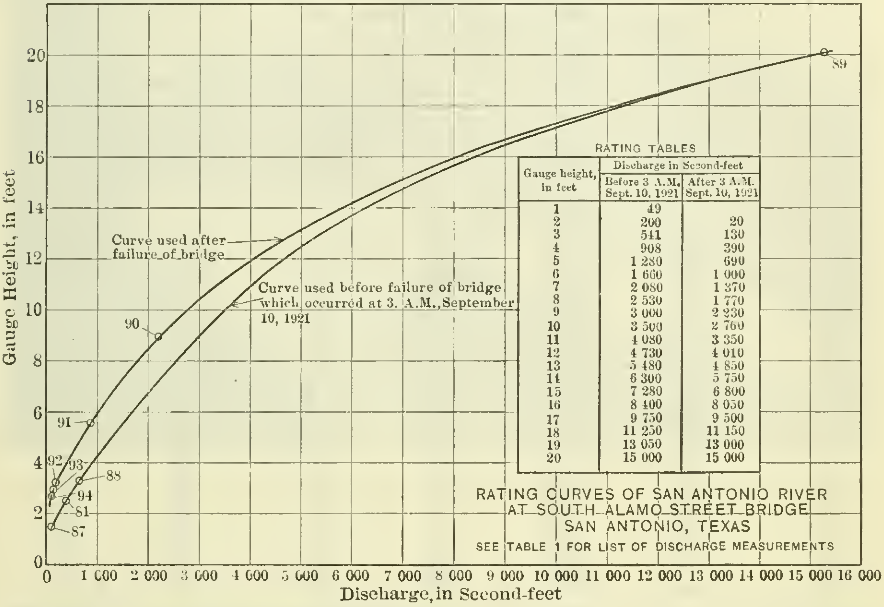

FIG. 9.

gauge. That effect has been determined quite definitely by comparison of measurements made before and after the flood, at relatively low stages. (See Fig. 9.) The difference in discharge between the curves, considered as a percentage of total discharge, would be less for higher stages and would be negligible at the crest; therefore, in the absence of definite information as to whether the blocks of concrete found in the channel after the flood were

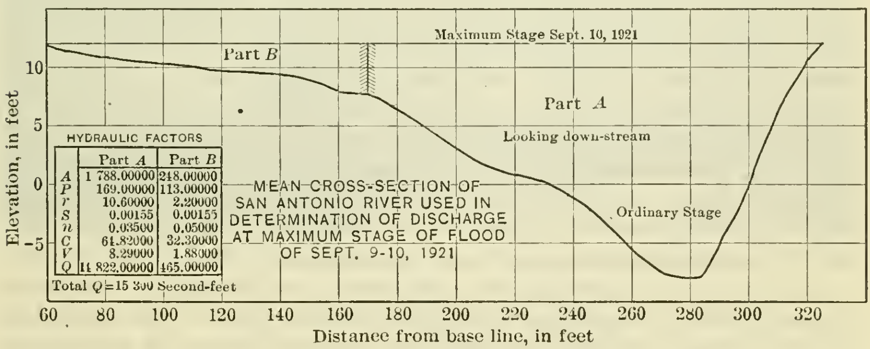

FIG. 10.

dropped there before or after the time of the maximum stage, both curves have been drawn through Measurement No. 89, which represents the discharge at the maximum stage.

TABLE 2.—GAUGE HEIGHT AND DISCHARGE OF SAN ANTONIO RIVER, AT SOUTH ALAMO STREET BRIDGE, SAN ANTONIO, TEX., DURING FLOOD OF SEPTEMBER 9TH-10TH, 1921.

Hour.	September 9th 1921:			September 10th, 1921:		
	Gauge height, in feet.	Discharge, in second-feet.	Run-off, in acre-feet.	Gauge height, in feet.	Discharge, in second-feet.	Run-off, in acre-feet
12-1 A. M.	1.30	68	6	11.93	4 690	388
1-2 "	1.45	80	7	14.30	6 040	499
2-3 "	1.92	176	15	18.50	12 100	1 000
3-4 "	2.52	369	30	19.40	13 800	1 140
4-5 "	2.98	534	44	17.49	10 300	851
5-6 "	3.13	588	49	15.40	7 300	603
6-7 "	3.29	645	53	13.38	5 190	429
7-8 "	3.44	701	58	11.61	3 760	311
8-9 "	3.18	606	50	9.95	2 740	226
9-10 "	2.92	512	42	8.72	2 090	173
10-11 "	2.67	422	35	7.67	1 640	136
11-12 "	2.68	426	35	6.40	1 140	94
12-1 P. M.	2.74	447	37	5.53	849	70
1-2 "	2.60	397	33	5.17	741	61
2-3 "	2.93	516	43	4.92	666	55
3-4 "	3.23	624	52	4.59	567	47
4-5 "	3.07	566	47	4.36	498	41
5-6 "	3.10	577	48	4.15	435	36
6-7 "	3.08	570	47	3.95	375	31
7-8 "	2.96	527	44	3.83	339	28
8-9 "	3.87	860	71	3.78	324	27
9-10 "	5.67	1 530	126	3.72	306	25
10-11 "	7.78	2 430	201	3.67	291	24
11-12 "	10.02	3 510	290	3.63	279	23
Mean..........	3.44	737	....	8.59	3 190	.....
Total..........	....	....	1 463	....	.....	6 318

The discharge at the maximum stage was determined by the slope method, by using Kutter's formula. The high-water slope had been well marked by floating oil. A stretch of straight channel, 800 ft. long, about 2 000 ft. down stream from the gauge, was selected. The center of this stretch is near the intersection of Temple Street with the river. Cross-sections were taken every 100 ft., and the slope was carefully measured on both banks. The slope on the left bank, for the upper 375 ft. and the lower 50 ft. of the stretch, was irregular and differed in form from that on the right bank. The left bank which is bordered by buildings and other obstructions, was overflowed but the right bank which is high, was not overflowed. The difference was probably due to these facts. For the intervening 375 ft., the slopes on the two banks were in close agreement, and the mean slope was used, the area being the mean of the area at stations at 400, 500, 600, and 700 ft. below the upper end. Fig. 10 shows the mean cross-section and a tabulation of the hydraulic factors. In making the computations, the cross-section was divided in two parts, because of different conditions of roughness and mean depth. The channel in the slope section is straight and relatively clean and unobstructed as compared with other parts of the river. Fig. 11 is a view of the channel looking up

Fig. 11.—View of Slope Stretch Used in Determination of Peak Discharge Looking Up Stream.

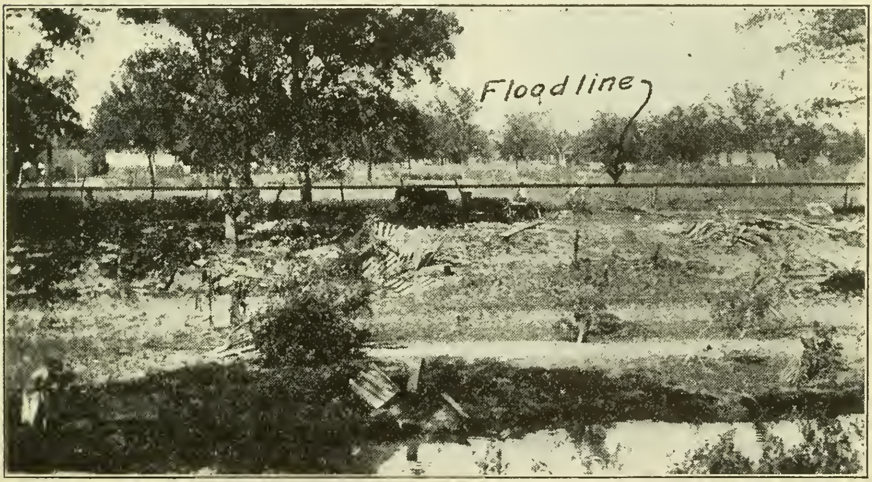

Fig. 12.—View from Right Bank near Center of Slope Stretch.

stream from a point on the right bank just below the lower end of the slope stretch, and Fig. 12 is a view from the right bank near the center of the slope stretch, showing the condition of the left bank and the flood line on it.

Fig. 13 shows a graph of the gauge heights of San Antonio River and San Pedro Creek. The water-stage recorder on San Antonio River did not operate when the stage was above 15 ft., during the period from 1.45 to 5.45 A. M., on September 10th, 1921. The estimated part of the graph, however, can not be greatly in error, because the maximum height of 20.14 ft. is clearly marked in the gauge house, and the time it occurred has been quite definitely established as 3 A. M., by statements of residents living near the gauge, who also have stated that the crest stage lasted about 30 min.

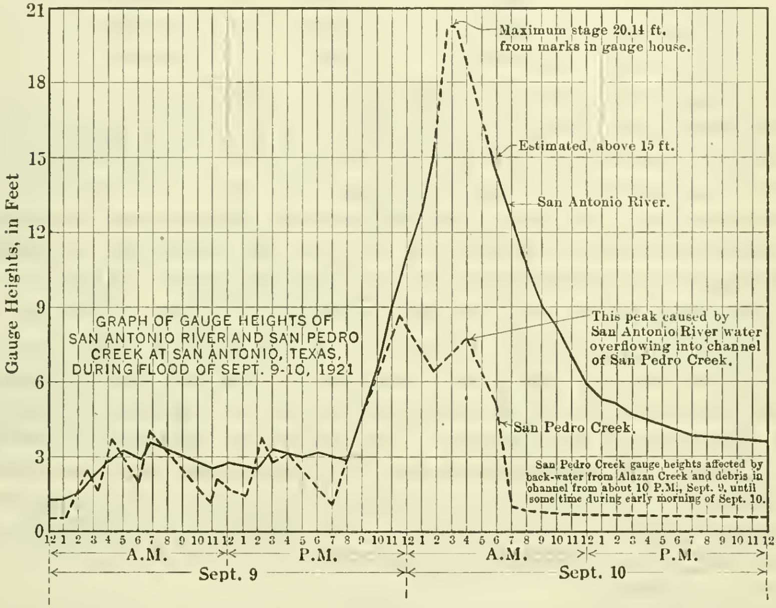

FIG. 13.

Table 2, which gives the mean hourly gauge height, discharge, and run-off, in acre-feet, from 12 A. M., September 9th, several hours before the flood began, to 12 P. M., September 10th, when the river had receded to nearly normal stage, shows that the most disastrous flood in the history of San Antonio was caused by less than 8 000 acre-ft. of water.

The water-stage register, on San Pedro Creek, is at the lower end of the covered part of the concrete-lined channel that extends from Durant Street to Arsenal Street. The graph of the gauge heights of San Pedro Creek is shown in connection with those of the San Antonio River, because of its possible value in determining the volume of water that passed over the divide from San Antonio River into the San Pedro Channel. The rise, shown in Fig. 13 as coming from San Antonio River, obviously did not come from any other source, as the flood-water from the San Pedro Basin had passed the gauge several hours earlier. It is impossible to compute with reasonable

accuracy the discharge of San Pedro Creek during the flood, because of an indeterminate volume of back-water from Alazan Creek. The following rating table for the San Pedro gauge is submitted for the benefit of any one who may be sufficiently interested to attempt to compute the volume of water that passed from the San Antonio River basin down the San Pedro Channel:

Gauge height, in feet.	Discharge, in second-feet.	Gauge height, in feet.	Discharge, in second-feet.
0.5	8	4.5	610
1.0	38	5.0	728
1.5	80	5.5	848
2.0	137	6.0	970
2.5	210	6.5	1 095
3.0	297	7.0	1 220
3.5	394	7.5	1 345
4.0	500	8.0	1 470

This rating table is directly applicable only at such times as back-water did not affect the San Pedro gauge heights. The time of the beginning and the ending of back-water is not definitely known, but it probably began about 10 P. M., September 9th, and lasted until some time during the early morning of September 10th. The rating table for San Pedro Creek is based on current-meter measurements for discharges of less than 200 sec-ft., and is extended for discharge for more than that rate, by Kutter's formula. Above a 6-ft. stage, the lined section overflows, and the rating is subject to large errors.

C. TERRELL BARTLETT,* M. AM. SOC. C. E. (by letter).†—The most important lesson brought out by both the San Antonio and Pueblo floods is that the experience of one or two generations is not sufficient to estimate safely the maximum flood dangers. The memory of the public in general is short, and in the many parts of the United States that have been settled only within the last 50 to 100 years, engineers, in too many instances, have based their judgment of flood discharges on the experience of a single generation or less, without thorough investigation of the traditions from even the preceding generation.

Where reliable records of flood discharges cover a period of less than 100 to 200 years, it appears that the most reliable estimates of maximum possible flood intensities can be based best on comparison of possible rainfall intensities with the storms that have produced floods of known dimensions. If such studies indicate flood magnitudes far in excess of the experience of one or two generations, and in cases where absolute safety is requisite, the engineer must have the courage to stand by his convictions in providing for the unprecedented. Had it not been for the old Spanish record of 1819, it is doubtful whether any engineer would have estimated a flood discharge more than double the greatest otherwise known at San Antonio.

Mr. Hazen's faith in the law of frequencies is amply supported by that San Antonio flood.‡ Save for this fragmentary Spanish record of more than a century ago, the 1921 flood might well have been regarded an anomaly,

* Cons. Engr. (Bartlett & Ranney, Inc.), San Antonio, Tex.

† Received by the Secretary, March 9th, 1922.

‡ *Proceedings*, Am. Soc. C. E., March, 1922, p. 707.

upsetting all theories of probability. However, it is found, as stated by Mr. Sherman,* that the estimated flood of 100-year frequency, as determined from rain storm intensities, is closely substantiated by two floods 102 years apart.

Another clue to possible flood stages is in the geological structure of a stream valley. Where there is a well-defined flood-plain structure, an estimated maximum flood discharge that does not correspond with a flooding of such valley, may well be questioned. An instance of this kind is in that part of the Rio Grande Valley in Southern New Mexico, known as the Mesilla Valley, where there has been no overflow of the entire flood-plain in historic times, but where Indian tradition tells of destructive floods. Fortunately, this valley is now protected by the Elephant Butte Dam.

With reference to the question of the discharge rates of the various streams at San Antonio, raised by Col. Jadwin,† all the estimates are based on measurements of slopes and cross-sectional areas, made after the flood, and no great accuracy can be expected. On reviewing the various estimates of flood discharge, the writer is of opinion that the values given in Table 3, may be finally recorded as the most probable crest discharge rates of the floods of September, 1921.

TABLE 3.

Stream.	Area of water-shed, in square miles.	Crest Discharge, in Second-Feet.	
		Total.	Per square mile.
Olmos	32.4	31 000	956
San Antonio	41	23 700	578
" "	45	16 000	356
Alazan Martinez	16.9	28 000	1 656
Apache	22	19 000	864

The variation in discharge rates per square mile do not seem unreasonable, on considering the differences in slopes, topography, and rainfall and, in the case of the San Antonio River, the pondage in the city.

The timely discussion by Mr. Ellsworth is of great value in showing the degree of accuracy obtaining in the Geological Survey estimates of discharge and in correcting a general statement of the writer, which might have been misunderstood.

As a resident of San Antonio and an observer of the 1921 flood there, the writer is impressed with the importance of the human or social aspects, as contrasted with purely economic considerations, in determining the extent and character of flood-prevention works. In cases where possible loss of life is a factor and where there may be many instances of ruinous individual losses, rather than a measured financial loss distributed on a whole community, the expenditures for preventing floods may justifiably exceed the amount computed by capitalizing the probable average annual flood losses.

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 801.

† *Ibid*, March, 1922, p. 708.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

THE AREA OF WATER SURFACE AS A CONTROLLING FACTOR IN THE CONDITION OF POLLUTED HARBOR WATERS

Discussion*

By Messrs. Kenneth Allen and H. W. Streeter.

Kenneth Allen,† M. Am. Soc. C. E. (by letter).‡—The extent to which polluted waters are improved by re-aeration is a matter of much importance to towns along the shores. It requires little acquaintance with the subject to be impressed with the difficulty of arriving at any reliable quantitative solution of the matter so largely affected, as it is known to be, by disturbances of the surface and the overturning caused by the wind, currents, changes of temperature, etc.

In general, the pollution at any point in a stream depends on (*a*) the dissolved oxygen at the source of pollution; (*b*) the oxygen demand of the polluted water at that point; (*c*) the amount of re-aeration occurring between these two locations; and (*d*) the depletion of dissolved oxygen that takes place between the two points due to biological action.

The technique for the first two determinations is fairly specific and reliable, but estimates of the re-aeration and biological demand that take place in transit are subject to so many influences, and the laws governing these phenomena are either so obscure or else so lacking common endorsement, that such estimates or forecasts should be carefully weighed and expressed without too much assurance.

Temperature plays an important part in the percentage of saturation of polluted waters, so that cold-weather observations are of little value. Also, as stated by Mr. Gould, the effect of winds and currents is great, so that reliable results can only be had from the average of many tests.

In tidal streams, there is a tendency to stratification, due to the lower specific gravity of the polluting sewage and the intrusion of the clean under-

* Discussion of the paper by Richard H. Gould, Assoc. M. Am. Soc. C. E., continued from March, 1922, *Proceedings*.

† San. Engr., Board of Estimate and Apportionment, New York City.

‡ Received by the Secretary, March 15th, 1922.

run from the ocean, so that dissolved oxygen determinations may be misleading if samples are not "representative". That this stratification may be greatly disturbed is quite apparent from cross-sections of salinity, as shown at different points in New York Harbor in the Final Report of the Metropolitan Sewerage Commission (salinity in this case being indirectly proportional to pollution). For this reason, any attempt to compute the oxygen supplied to the Upper Bay through The Narrows by the excess of the saturation on the flood over that of the ebb current, as the author has done with the Arthur Kill, would be misleading. Moreover, the constant change in conditions, due to tidal flow, introduces further complications. The dilution in a land-locked tidal basin is the ratio of the tidal prism to the volume of sewage entering during a tidal cycle. Other things being equal, a shallow bay, such as Jamaica Bay, has the advantage over a deep body of water, in that a larger proportion of its volume is discharged to the ocean with every ebb; for although the ultimate dilution is the same, at high tide a larger proportion is of new and, presumably, better oxygenated water.

The problem of re-aeration has been dealt with in an orderly way by Mr. Gould, and his results are presented in a clear concise manner. Fig. 3, on which computations of re-aeration are based, furnishes the information required in a convenient form. The writer, however, has been unable to check the results plotted from experiments of the Metropolitan Sewerage Commission, and, as the matter is of considerable importance, he hopes that the author will describe more fully, in his closure, how he arrived at these and his original experimental data. This is particularly desirable as the values he gives for re-aeration are considerably in excess of some others that have been published.

The absorption of oxygen per unit of surface is a most convenient figure to use, but in looking over the results of various experimenters it has been difficult or impossible to interpret them in this form without assumptions which do not seem to have sufficient sanction.

With regard to the rôle played by absorption from the air, E. B. Phelps, Affiliate, Am. Soc. C. E., states*:

"With the deep and relatively quiescent waters of New York Harbor re-aeration was found to be almost a negligible factor, the capacity of such a body of water to oxidize pollution is practically limited by the amount of available oxygen brought in from the ocean with each tide.

"In rivers the conditions are reversed, the initial volume of available oxygen is small compared with the total capacity of the stream to oxidize pollution. Re-aeration in rivers is the chief factor."

Adeney† also states, "when the atmosphere is calm and saturated with moisture, the rate of re-aeration will be practically at zero", but he points out further that this rule does not apply to other conditions and that "the rate of re-aeration must therefore be an extremely variable quantity".

As a matter of fact, the surface of the Upper Bay is nearly always more or less disturbed if not actually broken up by waves, and it has been shown by Adeney, Ellery, and Borst that this increases the rate of re-aeration to a marked

* Reprint No. 214, Public Health Reports.

† Report, Metropolitan Sewerage Comm., 1912, p. 81.

extent. This provides a sanction for using higher rates in practice than those determined experimentally with still water. Professor Phelps has estimated the effect of mixing due to vessels, wind, and tide, on re-aeration in New York Harbor, but, after all, the writer thinks it will be admitted that little is known about the actual rate of re-aeration in a specific case, for as yet there is no reliable measure of the influence of wind or humidity, either of which may safely be assumed to overshadow any rates for still water.

Dr. Hugh S. Cumming, of the U. S. Public Health Service (now Surgeon-General), found* in September, 1913, that in flowing from Washington to Fort Foote, in five days, the dissolved oxygen of the Potomac River was reduced from 8.13 to 4.88 parts per million. The oxygen demand of Washington sewage, however, as determined for that month, was 7.14 parts per million, which would have left only 0.99 parts per million on reaching Fort Foote. The remainder of 3.89 parts per million was made up by re-aeration.

A matter which is usually not considered, but which may have an important bearing on the oxygen content of a stream, is the regeneration of this gas by plant life. The plankton that abound in the tidal flats of the Potomac River have been estimated to furnish 17.7 lb. per acre daily of oxygen to the waters, under favorable conditions. It was computed by Mr. W. C. Purdy, in connection with the investigation of Dr. Cumming referred to, that with an oxygen demand of 300 parts per million, 1 000 000 gal. of Washington's sewage would require 2 500 lb. of oxygen for its decomposition, so that this could be accomplished by the plankton of 141 acres of tidal flats.

"In other words, this flat will provide sufficient oxygen for the first 24 hours' natural purification of nearly 30 million gallons of Washington's sewage * * *. Purely physical re-aeration * * * is certainly not over 33 per cent. of the total effect, and if proper allowance could be made for the residual biological action upon cloudy days, perhaps 6 per cent. of full sunshine, this figure would be materially reduced."

Although re-aeration by plankton is seen to be a factor of importance in situations similar to the one cited, it was pointed out by the late Emil Kuichling, M. Am. Soc. C. E., in his testimony in the Passaic Valley Sewer Case, that in the transition from fresh-water to sea-water conditions or *vice versa* these minute forms of vegetable life do not prosper, and it is probable that their influence in providing oxygen to such tidal bodies of water as are found in New York Harbor is not great.

Mr. Gould has estimated the quantity of dissolved oxygen available for the oxidation of the polluted waters of Newark Bay and indicated how this method may be applied to New York Harbor. Such computations aid in arriving at fair ideas of relative values and are generally illuminating, but much more definite knowledge of the influence of salinity, depth, wind, and humidity is necessary in questions of re-aeration, and regarding the draft on this supply by decomposing sludge beds, in order to predict results with confidence. Adeney, for instance, finds a rate for re-aeration in sea water 2.7 times that in fresh water, with an increase proportional to the depth to at least 6 ft., but leaves one in doubt as to greater depths, whereas Phelps makes the rate nearly inversely as to depth and directly proportional to the depletion, with

* See *Hygienic Laboratory Bulletin No. 104*.

corrections for the effect of mixing. As to the effect of sludge deposits, also, there is a wide divergence of opinion.

Taking Adeney's results, as applied to the Upper Bay during average August conditions, as well as can be told, and 1920 populations tributary to the Bay, the supply and demand of oxygen may be compiled as follows, ignoring, for the time, any demand by the underlying beds of sludge.

Population.—The population tributary to New York Upper Bay, assuming that sewage entering the Hudson River above Yonkers, N. Y., is oxidized before its arrival, is as follows:

New York City	5 231 100
Westchester County	182 600
New Jersey	1 671 200
Total	7 084 900

Water Areas.—

Hudson River below Mt. St. Vincent	421.2	million sq. ft.
Harlem River	21.5	" " "
Upper East River	280.2	" " "
Lower " "	116.8	" " "
Upper Bay	543.9	" " "
Kill van Kull	28.7	" " "
Newark Bay	224.	" " "

Stream Flow in August, per Tidal Cycle of 12 Lunar Hours.—

Hudson River	572 742 000 cu. ft.
East River, net ebb	100 000 000 " "
The Narrows, new sea water, entering on the flood	1 520 000 000 " "

The quantity of dissolved oxygen brought into New York Harbor by streams and utilized in oxidation of sewage, is given in Table 3.

TABLE 3.

Stream.	Reduction of saturation.	Dissolved Oxygen.	
		In parts per million.	In pounds per day.
Hudson River	80% to 37%	3.61	249 142
East River	90% to 22%	5.17	62 335
The Narrows	97% to 46%	3.76	689 106
Total	....	....	1 000 583

Dissolved Oxygen Supplied by Re-aeration.—Adeney states this to be at the rate of 0.03 cu. cm. per liter per hour, for completely de-oxygenated fresh water, increasing in proportion to the salinity to 0.08 cu. cm. per liter for sea water, and that this holds good for depths of 6 ft. If this is arbitrarily

assumed as a limit and also that the rate of re-aeration is directly proportional to the depletion found in the different bodies of water, it is found that:

Pounds of oxygen absorbed from the atmosphere in 24 hours = 0.01285 [0.03 + 0.05 (proportion of sea water times depletion of DO)],

the first coefficient being the pounds of oxygen contained in a column of water 1 ft. square and 6 ft. high containing 1 cu. cm. per liter.

Applying this to the problem in hand, Table 4 gives the following data.

TABLE 4.

Stream.	Percentage of sea water.	Percentage of dissolved oxygen.	Absorption coefficient, in pounds per square foot per day.	Oxygen absorbed per day, in pounds.
Hudson River	60.0	37	0.00049	206 000
Harlem "	62.3	22	0.00060	12 900
Upper East River	76.5	39	0.00052	145 600
Lower " "	74.8	22	0.00066	77 000
Newark Bay	50.0	15	0.00060	134 000
Kill van Kull	63.	30	0.00055	15 800
Upper Bay	78.6	42	0.00050	271 800
Total	....	....	....	863 100

The using of rates of absorption observed or suggested by Phelps and Ellery would give lower resulting values, whereas if the oxygen is carried by streaming to depths below 6 ft., the result would be increased.

Oxygen Demand of Sewage.—It is estimated that in 1920 the sewage of 5 413 700 persons in New York and 1 671 200 persons in New Jersey found its way to New York Upper Bay, or a total of 7 084 900 persons.

Langdon Pearse, M. Am. Soc. C. E., from many "tests on a large sewer serving 300 000 people, with no marked industrial wastes" finds* an equivalent of 0.22 lb. of oxygen per capita required for complete oxidation. The total demand for New York Harbor, therefore, may be estimated at 0.22 × 7 084 900 = 1 558 700 lb. We have, therefore,

Dissolved oxygen supplied by entering streams....	1 000 600 lb.
" " " " re-aeration	863 100 "
Total	1 863 700 lb.
Dissolved oxygen demanded of sewage............	1 558 700 "
Excess supply	305 000 lb.

This would seem to indicate that, under August conditions at least, the main supply of oxygen to the Upper Bay is from the incoming streams. Also, that if the sewage was well diffused and if there was no draft on the oxygen from underlying sludge, there would remain a balance of 304 400 lb., or one-sixth of the whole supply, to take care of further pollution. Additional proof is required, however, before a positive assertion as to true values can be made. It does not seem practicable, with the present knowledge of the subject, to estimate closely the influence of the wind and the stirring up of the water by

* *Proceedings*, Am. Soc. C. E., December, 1921, p. 638.

steamships and ferries in re-aeration, or that of decomposing sludge deposits in de-aeration.

Nevertheless, such studies as that which Mr. Gould has presented in this paper are most valuable aids in forming a correct opinion as to the present and future degree of pollution of a body of water, and great credit is due for the manner in which the subject has been prepared and presented.

H. W. STREETER,* ASSOC. M. AM. SOC. C. E. (by letter).†—This interesting paper deals with a problem which, although fairly simple in its fundamental underlying principles, is often extremely complex when an effort is made to apply these principles to a particular case. This is true not only of problems involving the re-aeration of semi-quiescent bodies of water, such as New York Harbor, but also of those which deal with the re-aeration of flowing streams, although in the latter case the factors entering into a solution of such problems are usually subject to more exact measurement. Whatever the type of the particular body of water under consideration, however, there are certain fundamental reactions which must be taken into account in determining its re-aeration capacity.

The changes which occur in the reserve dissolved oxygen content of all polluted bodies of water are governed by two reactions, each of which is progressive to a large extent and more or less independent of the other. The first of these is a progressive withdrawal of dissolved oxygen from solution in order to satisfy the oxygen demand of the oxidizible organic matter present in the water. This is essentially a bio-chemical reaction, requiring, for its progression, three elements: (*a*) oxidizible organic matter; (*b*) reserve oxygen in solution; and (*c*) oxidizing bacteria to act as carriers of the reaction.

The second reaction consists of a replenishment of the reserve oxygen supply through: (*a*) additional dilution water containing oxygen; (*b*) liberation of oxygen by certain forms of aquatic plants; and (*c*) physical solution of oxygen from the atmosphere. The addition of oxygen through the medium of dilution water is a matter of physical admixture, its relative importance in any case depending on the quantity of water added and the rate at which it becomes thoroughly mixed with the body of water under consideration. The addition of oxygen through biological re-oxygenation and atmospheric re-aeration, however, are both essentially progressive reactions, dependent, for their rates of progression, on a highly complex series of factors widely differing in the two cases. Thus, purely biological re-oxygenation, which has been referred to by Mr. W. C. Purdy‡ as being a possible factor of great importance in the re-aeration of tidal estuaries near New York Harbor, depends on the presence of certain plants and their essential food elements, together with a highly complex series of environmental conditions favorable to their activity. Among these the influence of light has been emphasized by the work of Purdy, Forbes, and others, which has shown that where biological re-oxygenation exists, its progress is greatly stimulated during daylight and greatly retarded during darkness.

* San. Engr., U. S. Public Health Service, Joliet, Ill.

† Received by the Secretary, March 31st, 1922.

‡ *Proceedings*, Am. Soc. C. E., March, 1922, p. 711.

Atmospheric re-aeration, however, is wholly a physical reaction, dependent primarily on the rate of solution of atmospheric oxygen at the water surface. This rate is a direct function of the proportion of oxygen in the overlying atmosphere and is likewise directly proportional to the deficit in oxygen saturation existing momentarily at the absolute surface.* If complete and absolute stagnation existed in the body of water under consideration, the quantity of oxygen absorbed directly from the atmosphere would be relatively small, since, as has been shown by Phelps,† once the extreme surface film of water became saturated with oxygen at the partial solution pressure existing under atmospheric air, the penetration of oxygen to lower strata would be dependent on diffusion, which is a slow process, once a gradient has become established. Available evidence indicates, however, that complete stagnation is practically never attained in natural bodies of water, even under conditions of extreme quiescence. Under these circumstances, the extreme saturated surface film is being constantly broken up and replaced by under-saturated particles of water, the presence of which, in contact with the atmosphere, restores instantly the solution reaction. The actual rate of solution, therefore, is governed largely by the rate of surface replacement of saturated water by partly de-saturated water. In flowing streams, where the replacement rate is extremely high, its progression is determined almost wholly by conditions influencing turbulence of flow, as extensive observations in the Ohio and Illinois rivers, by the U. S. Public Health Service, have shown. In quiescent and semi-quiescent bodies of water, this rate, although undoubtedly lower than in flowing streams, is governed primarily by the same factor of vertical circulation, which, in streams, is termed "turbulence". The work of Sanborn‡ has indicated that wind action may be, and probably is, responsible for a large part of the variation taking place in the degree and depth of vertical mixing of quiescent bodies of water. Other things being equal, this factor is probably a far more important one in determining the re-aeration of bodies of water exposed to wind action, than the increased surface area gained by the water under such circumstances.

The point, which the writer particularly desires to emphasize, however, is that whenever a polluted body of water is exposed to progressive re-aeration, the processes of de-oxygenation and re-oxygenation proceed according to two virtually independent reactions. Whenever the rate of de-oxygenation exceeds that of re-oxygenation, the dissolved oxygen content will be progressively lowered until either a sufficient proportion of the initial oxygen demand has been satisfied or sufficient additional re-aeration capacity has been attained to bring about an equalization or actual reversal of the two relative rates. From this point, a recovery of reserve oxygen sets in, disturbed only by the introduction of fresh pollution or by modification of the re-aeration rate. In streams, such as the Illinois River which receives the greater part of its

* This is merely a direct application of the law of velocity of solution derived experimentally by Noyes and Whitney, *Zeitschrift für Physik. Chemie*, Band XXIII (May, 1897), p. 689.

† Report on Pollution of New York Harbor, Board of Estimate and Apportionment, New York City, 1911.

‡ "A Theory of the Water Wave", *Transactions*, Am. Soc. C. E., Vol. LXXI (1911), p. 284.

pollution at a point near its head-waters, the influence of changes in the balance of these two reactions on the retrogression and subsequent recovery of reserve oxygen by the river may be traced for many miles below a point of major pollution.

Interpreting the author's data from the standpoint of the foregoing principles, it is evident, first of all, that a true measure of progressive re-aeration in bodies of water similar to New York Harbor, whether from biological or atmospheric sources, cannot be obtained without taking into account both the initial and residual oxygen demand of these waters, the difference, when corrected for changes in dilution, representing the amount which has been satisfied during the particular cycle of observations. If the dilution factor finally becomes sufficiently great in the outer harbor to reduce the residual oxygen demand to a value so low that it cannot be measured, the problem is virtually indeterminate, as the base line necessary for measuring the quantity of oxygen demand actually satisfied (and, consequently, the quantity of oxygen absorbed from solution), has been destroyed. It would hardly appear, however, that this need necessarily be the case, provided that sampling stations are carefully selected, with the end previously stated in view, and provided, further, that determinations of residual oxygen demand at these stations can be corrected for the demand of the diluting sea water.

A further complication in calculations of this kind lies in the importance of the time factor in all the progressive re-actions which have been noted. In a flowing stream, this factor may be determined with a fair degree of accuracy, but, in tidal bodies of water, the problem is often rendered almost hopelessly complex by the vagaries of tidal movements, accompanied in some cases by marked and sudden changes in dilution. Where the age of a given body of polluted water, as measured by the time elapsed between entering and leaving the harbor waters, is relatively long, say, 5 to 10 days, the error involved in approximate assumptions bearing on the time factor is not great, but where it is so small as to fall within limits of 2 or 3 days, the error involved in such assumptions may be considerable. The assumption made in connection with the author's calculations, judging from his use of the 48-hour oxygen demand as their basis, would appear to fall in the latter category.

In connection with the figures given by the author, relative to the 48-hour oxygen demand of New York sewage, it may be of interest to note that experiments conducted by the U. S. Public Health Service in connection with stream-pollution studies in the Ohio and Illinois rivers have indicated that at a temperature of 25° cent., an average of approximately 44% of the total oxygen demand is satisfied in 48 hours in normal composite city sewage. This figure, which is based on experiments made on the sewage of Washington, D. C., Cincinnati, Ohio, and Chicago, Ill. (in the last-named case at the outlet of the Drainage Canal), is close to the Metropolitan Sewerage Commission's figure of 48% cited by the author, but considerably lower than the Adeney figure given. A point of doubt concerning all figures of this kind, where they are based on small-scale laboratory incubation experiments, is as to whether a particular rate as determined in the laboratory would necessarily hold true for the same water or sewage in a natural body of water. An

effort is being made, in connection with studies now being conducted by the Public Health Service in the Illinois River, to establish a basis for measuring the rate at which the oxygen demand is actually satisfied in the stream itself, applying principles which have been stated in connection with this discussion.

The curve shown in Fig. 3*, defining the rate of absorption of dissolved oxygen by water at different degrees of saturation, illustrates in an interesting and practical way the relation between these two variables as determined experimentally. Although the curve does not follow closely the law of velocity of solution previously noted, it would hardly be expected that an experimental curve of the kind would do so, in view of the interference which diffusion and vertical circulation would presumably offer to a measurement of the theoretical relation. It affords a practical basis, however, for interpreting the law under conditions closely approaching those of the experiment, and it is hoped that further work along similar lines can be undertaken. Further information regarding the methods used in experiments would be of much value to investigators in this field.

Finally, it may be worth while to emphasize the point made by Mr. Purdy in his discussion†, namely, that in casting up a balance sheet between the oxygen demand and available sources of oxygen to satisfy such demand, the possible influence of intensive biological activities in shallow bodies of water, similar to those of the tidal flats near New York Harbor, can never be safely overlooked. Whenever a marked and fairly regular increase in dissolved oxygen is noted during the daytime in a particular locality, as is exemplified by the author's observations in the Arthur Kill,‡ the presence or absence of aquatic plant organisms capable of liberating oxygen may be a factor of prime importance.

The author has rendered a real service in presenting the results of his study. It is hoped that further studies of the difficult and important problem with which his paper deals, will be made in the future, in order that correlations of fundamental importance in connection with problems involving the self-purification of both streams and tidal bodies of water may be established.

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* *Proceedings*, Am. Soc. C. E., December, 1921, p. 609.

† *Ibid*, March, 1922, p. 711.

‡ *Ibid*, December, 1921, p. 615.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

HIGHWAY TRANSPORTATION
A SYMPOSIUM
Discussion*

By M. S. Ketchum, M. Am. Soc. C. E.

M. S. Ketchum,† M. Am. Soc. C. E.—In 1921, the Civil Engineering Department of the University of Pennsylvania, in co-operation with the State highway departments of adjacent States and the Federal Bureau of Roads, gave a three weeks course in Highway Engineering. The course consisted of lectures, recitations, and laboratory work. The instruction in laboratory work was given by the Staff of the Civil Engineering Department, assisted by engineers from practice who had had a large experience. The course was attended by 67 men, varying in age from 19 to 59 years, with an average age of 30 years. All the men attending the course had had extensive experience in highway engineering and many of them were technical graduates.

The second session of this course was given from January 23d to February 10th, 1922. In addition to the subjects offered in 1921, work was given in Contracts and Specifications and in Maintenance of Highways. H. E. Hilts, Assoc. M. Am. Soc. C. E., Principal Assistant Engineer of the Pennsylvania State Highway Department, had charge of the subject of Contracts and Specifications in which particular attention was given to the duties and responsibilities of an engineer in charge of work.

The brief course in Engineering, in which the instruction is given by engineer specialists in various lines, offers an opportunity for practicing engineers to keep up with modern developments in design and construction. It also offers an opportunity for the practicing engineer to give material assistance in engineering education, and will also bring about an active co-operation between engineers in practice and teachers in engineering schools. This co-operation should be of great value in developing the laboratories and arranging the various courses of study. Large business organizations are founded on much the same lines as educational institutions. The manager

* Continued from March, 1922, *Proceedings*.

† Director, Civ. Eng. Dept., and Prof. of Civ. Eng., Univ. of Pennsylvania, Philadelphia, Pa.

or chief engineer is practically the president of the educational institution; the assistant engineers are instructors, and the inspectors and foremen are assistants. The idea of the organization is to educate all the men in the organization, including the common workmen. The engineer and the contractor, instead of working at cross purposes, are in active co-operation. With this modern organization, the technical graduate is much more serviceable than he was a few years ago. Engineering graduates have always been criticized; they always will be criticized. They are young; they have the faults of youth, but the fortunate thing about young men is that if one gives them time, they will always get over their youth.

AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

SOME NOTES ON THE LOCATION AND CONSTRUCTION OF LOCKS AND MOVABLE DAMS ON THE OHIO RIVER, WITH PARTICULAR REFERENCE TO OHIO RIVER DAM NO. 18

Discussion*

By Messrs. Earl I. Brown, William W. Harts, and L. M. Adams.

Earl I. Brown,† M. Am. Soc. C. E. (by letter).‡—The improvement of the Ohio River for navigation purposes, under the present project, is a problem of intense interest to all engineers who have been connected therewith. Literature on the subject describing the locks and dams and the methods of construction used to meet the special problems that arise in connection therewith, is scarce, and Mr. Hall's paper is a valuable contribution to it.

As explained by the author, the project for improvement has been carried forward progressively from Pittsburgh, Pa., toward the lower end of the river to such an extent that practically all the locks and dams between Pittsburgh and Louisville, Ky., either have been completed or placed under construction, as well as several between Louisville and Henderson, Ky. The experience gained in the construction of these locks and dams has been such as more or less to crystallize and systematize the methods of construction for these structures. The methods described by the author for Dam No. 18 may be taken as representative of the later practice in the construction of locks and dams on the upper part of the Ohio River as far down as Dam No. 31, at Portsmouth, Ohio.

Practically all the dams from Pittsburgh, to and including Dam No. 31, are founded on rock. This fact simplifies the construction on account of the inability of the current to erode the bottom of the river when the bed is contracted by the coffer-dams utilized for construction purposes. In several instances, on dams below Dam No. 31, constructed on sand and gravel foundations, extensive erosion of the banks and bed of the stream has occurred during freshets, due to the presence of the coffer-dams. This has resulted in

* Discussion of the paper by William M. Hall, M. Am. Soc. C. E., continued from March, 1922, *Proceedings*.

† Col., Corps of Engrs., U. S. A., Wilmington, Del.

‡ Received by the Secretary, March 8th, 1922.

difficult and expensive work in filling the eroded area and in replacing damaged parts of the coffer-dam and other structures.

The quantity of sediment carried by the river in times of flood also varies greatly in different parts of the river, increasing from the head-waters downward. In the upper half of the river, construction work was not greatly hindered by deposits in the working area within the coffer-dams during floods, but, in the middle and lower sections, these deposits become very great and cause considerable loss of time and great expense for their removal after the freshets subside and before construction operations may be resumed. Dam No. 48, near Henderson, Ky., is the lowest one of the series on which any work has yet been attempted, and its history has been one of great difficulties encountered and unexpected cost from shifting sand and damage by flood and deposits.

These conditions have led to a reconsideration of the project, with a view of meeting these increasing difficulties by some modification of the plan. Studies have been made with reference to the possible elimination of all locks and dams below Dam No. 49 and a substitution therefor of a system of improvement by regulation. It has been pretty well established that a system of regulation by open channel work below Dam No. 49 is feasible, but that the expense of such a system of regulation would exceed the cost of locks and dams above the mouth of the Tennessee River at Paducah, Ky. Below Paducah, it is probable that improvement by regulation would not be more than 50% of the cost of improvement by locks and dams. This is due to the fact that this part of the river, about 47 miles in length, is affected by back-water from the Mississippi River at Cairo, and the low-water discharge is practically doubled since the Ohio receives the discharge from the Tennessee River, the low-water discharge of which is practically equal to that of the Ohio. It may be stated, therefore, that these studies indicate that the project might be modified further to advantage, by the elimination of Dams Nos. 53 and 54 in that section of the river between Paducah and Cairo.

By reason of shifting sand bottom, broad channel of the river, lack of rock foundation within reasonable reach of the surface, and small low-water discharge, the construction of dams from No. 48 downward will be difficult. Moreover, back-water from the Mississippi River extends its influence up the Ohio River at low water to great distances, practically to the location of Dam No. 49.

Since the coffer-dams in which these structures are built cannot with safety be constructed to exclude freshets of more than 16 to 18 ft., the number of working days possible during the year depends on the number of days the river, at the site of the dam, is at and below these stages. In the upper part of the river, where construction has heretofore been carried on, the number of days the river is at and below these stages is relatively large, averaging well over 100 days per year. In contrast, an examination of the records of the stages of the river at Cairo, near the location of the proposed Dam No. 54, shows that the river is at and below an 18-ft. stage only about 60 days in the year, leaving only about 2 months available for active construction work.

The present types of coffer-dam, therefore, would become increasingly inefficient as the work progresses down stream.

In those locks that are not founded on rock, certain modifications of features, previously considered to be standardized, have been found desirable. To prevent a leakage under these structures through the sand and gravel foundation, it has been found necessary to provide a cut-off wall of steel sheet-piling extending continuously across the river from the lock to the abutment and penetrating the bottom to a depth of from 30 to 40 ft. This cut-off wall is also carried entirely around the chamber of the lock so as to exclude leakage into the chamber. With this continuous cut-off wall, it has been found possible to omit the concrete floor of the lock, which has hitherto been provided, and to substitute therefor a layer of broken stone about 2½ ft. thick, at much less expense. Most of the locks heretofore constructed have been provided with a Poirée dam at each end, for the purpose of unwatering the lock when making repairs to the chamber and gates. It has been found feasible to omit this, utilizing instead a short section of ordinary box coffer, which can be placed in position in about the same time as the Poirée dam and which reduces the first cost of the lock by several thousand dollars.

Most of the locks heretofore constructed have been provided with rolling gates, which type was developed to suit local conditions on the Upper Ohio River. On the lower part of the river many objections have developed to the rolling gates, and it has now been definitely decided to construct no more dams with this type of gate, but to use instead the ordinary mitering gates. The principal objection to the rolling gate is the fact that it requires one or two weeks at the beginning of each season after the freshets subside to place the gates in commission, by reason of the difficulty experienced in removing deposits of mud and sand which accumulate in the gate recess. It has been found impracticable to seal these recesses sufficiently to exclude the deposits of fine mud and sand, which are carried by the winter floods and which increase greatly in quantity with distance down stream. This trouble does not occur with the mitering gates, and the expense of construction is not greatly different from that of the rolling gates.

In the operation of this system of locks and dams, much trouble has been experienced by reason of inability to raise the dams at stages higher than about 9 ft. This results in the impounding and holding back of the discharge of the river in the pools of those dams that are raised, with a consequent rapid falling off in the discharge of the river at points lower down. So great has this effect on the discharge of the river become, that much delay and obstruction to navigation has at times been experienced at and below Louisville, by reason of the manipulation of the dams at and above Cincinnati. As the number of dams in operation increases, the effect on the lower part of the river will become more and more marked, and, at times, may result in an almost complete absorption of the discharge of the river, if great care is not exercised in the raising of the upper dams.

To meet this difficulty, a comprehensive scheme of control of operating the dams will have to be devised, so that constant reports as to the stages of the river and variations of discharge may be received at a central point, at

which will then be determined the proper time for the raising and lowering of all dams, and thus regulate them so as to affect the discharge in the lower parts as little as possible. A telephone system is being provided, connecting all dams to a central point, which will probably be Cincinnati, and that will be the point from which this centralized control will be exercised. After some means can be devised whereby the dams can be raised at stages above 9 ft., much benefit will be gained, and it is understood that attempts are now being made to devise some method of raising the dams at higher stages.

On several of the locks and dams, experiments have been made in the use of steel sheet-piling for the construction of coffer-dams, with some degree of success in the matter of increasing the number of days on which construction operations can be begun. This experiment is being carried out most fully at Dam No. 34. It is hoped that additional information covering this mode of construction will soon be available, as a request has been made that the engineer in charge of the construction of this dam prepare a report on that type of coffer-dam.

WILLIAM W. HARTS,* M. AM. SOC. C. E. (by letter).†—To those members of the Profession who are interested in the navigation of inland rivers, the author's painstaking and excellent paper should be welcome as a valuable addition to their information on this subject.

Much has been written on the engineering projects undertaken on the Ohio River during the last fifty years, but it has been mainly since the adoption, in 1875, of the present method of slack-water by means of movable dams, that this river has acquired a great engineering interest. It may be stated positively that the present slack-water system of the Ohio River is unsurpassed anywhere in the world, for suitability to local conditions, practicability in operation, economy of cost and maintenance, and success in meeting physically the needs for which it was adopted.

For many years, much attention has been devoted to the details of this system, and examples of successful practice elsewhere in the world have been examined and studied and often combined with new inventions in a project for this stream, which now challenges the admiration of engineers generally for its excellence and success.

The east and west direction of the course of the Ohio, so fortunately parallel to the great east and west freight movement in the area south of the Great Lakes, together with the large deposits of coal along its head-waters, often on the very banks of its tributaries, gave an enormous importance to the navigation of this river in earlier years and stimulated the need of better channels and depths as the pressure for fuel increased in the West, and as the size and unwieldiness of coal fleets increased.

Already, some of the tributaries had been made the subject of engineering attention by the States through which they passed, and their steep slopes had been overcome during these earlier years by slack-water projects, using locks and fixed dams. Through these developments the coal on some of these tributaries could be brought out more easily during the year and held in

* Col., U. S. A., Washington, D. C.

† Received by the Secretary, March 8th, 1922.

pools ready to float down the Ohio in huge fleets on the spring floods, to supply the growing markets of the Lower Ohio and Mississippi Rivers.

This important traffic in coal, thus commenced, grew in later years to an enormous volume, reaching, in 1900, nearly 15 000 000 tons. It was only natural that it should have been the early aim of the Government engineers to use the well-known slack-water system, already applied to some of the tributaries, for application also to the Ohio River, but until the early objection to the fixed dams of the tributaries could be overcome nothing could be accomplished.

The Ohio is subject to extreme floods. Sometimes, as much as 70 ft. in range is recorded, and great injury and loss invariably result to the towns along the banks. Nothing could be allowed in the bed of this stream that would be likely to increase this range, and in the public mind fixed dams were objectionable for this reason. Large quantities of sand and mud are carried down at each freshet, which, it was feared by some, might fill the channels if fixed dams were used and thus ruin the existing navigable depths, and, furthermore, the pilots of the towboats which guided the great fleets of coal barges down the Ohio at high stages, would not consent to any obstruction that might make the management of these fleets more difficult at open-river stages. A movable dam of some type was believed to be necessary to meet these objections.

Accordingly, search was made everywhere for types, and the following were finally found to be the best suited to the condition, namely, wickets, such as the Chanoine, needles, such as the Poirée, and bear-traps, an invention of the lumbermen who used this kind of dam to create an artificial wave to float out lumber rafts on the head-waters of streams of small flow. After trial on one of the tributaries, the needle type was abandoned for use on the Ohio, and bear-traps were adopted as a regular device for controlling levels.

The first dam was of the wicket type, of low lift, and was authorized by Congress in 1875 on the recommendation of the late Col. W. E. Merrill, Corps of Engineers. U. S. A., M. Am. Soc. C. E., who, with much justice, has been called the "Father of the Ohio River Navigation". Much study since the construction of the first dam has produced the present type of structure, and in 1910 the canalization of the entire river was authorized by Congress at a cost, then estimated, at $63 000 000. Before that time, the engineering features had been mainly standardized in practice, but new improvements were eagerly sought. The author's description of these standard designs, as applied to Lock and Dam No. 18, are clear and instructive. It is believed that a further discussion by him of his reference to the economics of the entire project as viewed under present conditions, would have been enlightening and profitable.

The enormous development of the steel industry in the Pittsburgh region and the corresponding increase in the demand for coal for smelting purposes have led to the more perfect control of the coal measures of the Western Pennsylvania regions by the steel companies, with a view to conserving the present stock. This has succeeded so well that a large volume of coal no longer seeks a market by the Ohio River; this export has been almost stopped, and coal is even imported to the Pittsburgh region from the West Virginia fields.

Furthermore, the development of the Alabama coal mines and the discovery of oil in Oklahoma have reduced the fuel demands for Ohio River coal in the Lower Mississippi Valley. The low cost from the newer mines of Western Kentucky and Southern Illinois also reduces the demand for Pittsburgh coal. All these influences have had a marked effect on the commerce of the Ohio River of late years. In 1900, the commerce, principally coal, amounted to about 15 000 000 tons, whereas in 1920 it had fallen to about 5 000 000 tons. Thus, it appears that in about 20 years the commerce had dwindled to about one-third of its former proportions, notwithstanding that, in the meantime, many troublesome shoals had been eliminated by the new locks and dams which were completed from time to time, thereby materially increasing facilities for navigation, as may be seen from the fact that thirty-three of the proposed fifty-four locks and dams had been completed by the latter date.

If the traffic diminishes, the overhead costs, being more nearly fixed, increase relatively, but are still a proper charge against the costs of water transportation. The main interest which the public, as a whole, has in works of this character, is in the saving that may be made over other kinds of transportation, in money or its equivalent. On no other basis can works of this class be justified economically. The overhead charges for interest on the first cost, depreciation, and other annual charges, together with the cost of maintenance of the channels by the public, is undeniably a part of this cost of transportation and must be added to the shipper's cost of water haulage to ascertain whether the actual cost of transportation by water is less than by other means. A short computation should reveal the facts in this regard. If there is thus shown to be no saving or a loss in developing transportation by water rather than by other methods, all features considered, the enterprise cannot be classed as an economic success and its value as a public venture may be negative. In such a case, may not the expenditure of public funds on such works be criticized as of questionable propriety? Are there any important considerations other than an economic justification that may warrant the great outlay for such works?

It seems plain that engineers should never permit themselves to be lured from the true economic solution of such transportation problems by the blandishment of local commercial organizations which sometimes desire large sums to be spent in their localities with only a minor regard for the National service or the economic success of the project; nor should engineers permit themselves to be misled by glittering speculative estimates of future traffic that a more careful study would show could never develop.

The supreme test of the public value of any inland waterway must always be an economic one. Can the actual ton-mile costs to the shipper of hauling by barge and towboat, or by other similar means, when added to the ton-mile cost of interest on the first cost, depreciation, and maintenance of the waterway now borne by public taxation, effect, when combined, a saving over other means of transportation? How many of the inland streams, on which extensive navigation projects have been built, can now meet this test?

The low credit of the railways and the resulting cramping of their development of late years by the present public policies, may have a serious effect in the

future, when a new prosperity shall follow the present depression. When that time comes, many years and much money may be necessary before the companies can replace their railways on a basis sufficiently broad to handle the volume of traffic presented. At that time, water transportation may perhaps be considered, to supplement other methods, and many of the waterways may then arrive at a new prosperity and public usefulness. How permanent and extensive this might become is, of course, subject to the usual economic laws from which there is no escape.

L. M. ADAMS,* M. AM. SOC. C. E. (by letter).†—The author's interesting paper can be read with great profit by any one who may have similar works to build in a river subject to sudden and irregular flood stages, such as the Ohio.

It was the writer's good fortune to have considerable to do with the design of the later locks and dams on the Ohio River, and it is his recollection that the controlling idea in adopting the Chanoine type of movable dam for the Ohio River system was on account of the peculiar method, so much in vogue, of making up, during ordinary river stages, great fleets of loaded coal boats, which moved down stream on subsequent rises of the river. These fleets were so large that the stern-wheel towboat which controlled them, could do no more than steer the floating raft and, where conditions warranted, return to the Pittsburgh Coal District with the empty barges many weeks later. The custom had become fixed of handling fleets of barges in this manner and the mere suggestion of placing fixed dams in the river, which would require the fleets to be broken up to pass through the locks, brought violent opposition which could not be overlooked.

As practically all the tonnage movement was down stream before and during the period the movable type of dam was adopted, the question arose at the time, whether it would not be more desirable to build fixed dams of comparatively low lift, say, 6 ft., with the idea that during fair sized floods these low fixed dams would be drowned and the coal fleets could pass down the river in the accustomed manner, special care being used not to start until the disturbance at the dams had become a safe minimum. However, the necessity of slightly increasing the flood heights with consequent complaints and claims from riparians, and the determined opposition of those who navigated the river, resulted in the abandonment of the idea of the fixed dam and the acceptance of the movable dam in lieu thereof, in spite of its enormous first cost and large cost of operation. Thanks to the long experience of the French in successfully operating movable dams and the valuable experience gained in building and operating several similar dams of earlier date along the Ohio River, it was not a difficult matter to design movable dams of unprecedented height and length. Many interesting features arose during the two years occupied in designing the new system, such as whether transverse rolling gates should be used instead of the more common mitered gates; whether the dams should be built on piling, or excavation be continued to bed-rock at somewhat greater expense; whether the dam foundation should be built solid or be of cellular construction; whether it was desirable to install

* Maj., Corps of Engrs., U. S. A., Galveston, Tex.

† Received by the Secretary, March 14th, 1922.

water turbines in the structure or to take advantage of the low-head power within reach when the dam was up; whether to use the expensive bear-trap weirs, in addition to the long sections of Chanoine weir at each site; and, finally, whether fixed dams of considerable length could not be advantageously used at some of the sites, particularly in the lower river where the fall was slight, the river wide, and ample notice of approaching floods was always available.

It so happened that one of the early dams to be considered was Dam No. 48, below Evansville, Ind. It was evident from a study of the survey of the river that the situation here was different from that several hundred miles farther up stream. Unless the plans were afterward changed for other good reasons, Dam No. 48 contained the innovation of omitting the pair of standard bear-trap weirs. On the lower Ohio River, there always is sufficient warning of the approach of floods, to afford ample time to lower the Chanoine weir, thus offsetting the great advantage of the bear-trap type of weir, namely, speed and power operation. Furthermore, a decided saving in the cost of the dam and in the time required for construction appeared possible by the omission of the bear-traps. The width of the river at this site was so great that if a standard type of construction, like that in the upper river, had been followed, it would have meant the building of a 700-ft. navigable pass, two standard 91-ft. bear-trap weirs, and 1 400 ft. more of expensive Chanoine weir. It seemed desirable to reduce the length of weir, and calculations were made with that object in view. The discharge of the Ohio at low-water elevation, at Dam No. 48, was computed to be 7 160 cu. ft. per sec.; at the 7-ft. stage on the navigable pass sill, the discharge became 26 000 cu. ft. per sec.; and at the 9½-ft. stage above the navigable pass sill, which corresponded to a 7-ft. stage above low water, the discharge became 48 000 cu. ft. per sec. As is well known, the discharge for certain stages is greater on a rising, than on a falling river. Careful inquiry was made among the lock-masters in the Wheeling District and in the Pittsburgh District to ascertain at what maximum stage of the river, the typical Chanoine wickets of the pass could be raised with certainty. It became apparent that there would be no detriment to navigation, if, on a falling river, the stage was allowed to fall somewhat below 9 ft., as all the larger barges (known as "boats") would have passed down before this, and the raising of the dam could be safely delayed until the stage had fallen to 7 ft. above low water. Therefore, it was concluded in the design of Dam No. 48, that:

First.—It was unnecessary to arrange pass and weir so that the pass could be raised on greater stages than about 9½ ft. over the pass sill or 7 ft. above low-water gauge.

Second.—It would be possible to raise the pass wickets against a head of 5 ft. and this would mean that the final closure of the pass at the 7-ft. stage of the falling river would be made with the upper pool about 13½ ft. above the pass sill and the lower pool about 8½ ft. above this same level.

With the weir at Dam No. 48 designed to pass the discharge of a 7-ft. stage of 48 000 cu. ft. per sec., with the upper pool at 13½ ft. above the sill,

any delay in closing off the pass could not result seriously, as the difference between pool elevations would not then increase above the allowable 5 ft., and, as a matter of fact, the lower pool under such condition would begin to re-approach the 7-ft. stage and the head to decrease slightly and this again would cause a slight rise in the upper pool until equilibrium was established. By calculation, it was found that when the upper pool was at 13½ ft. above the pass sill and the lower pool at 8½ ft. above the same point and the river was falling, each foot of navigable pass would discharge about 125 cu. ft. per sec., each foot of Chanoine weir would discharge about 80 cu. ft. per sec., and each foot of the bear-trap weirs, if installed, would discharge about 120 cu. ft. per sec., these figures neglecting velocity of approach and end construction. It then became a simple matter to determine the length of Chanoine weir necessary to discharge 48 000 cu. ft. per sec. Neglecting the 2 000 cu. ft. per sec. as the minimum escaping between the pass wickets, it appears that 600 ft. of standard Chanoine weir should suffice to prevent the head against the pass wickets from rising above 5 ft. on finally closing. If it had been desired to introduce two standard bear-trap weirs in this work, they would have provided about 19 600 cu. ft. per sec. in themselves, and the length of Chanoine weir necessary would have become about 355 ft. As, at that date, two bear-trap weirs, with piers and piping, were estimated to cost $180 000 and the equivalent length of Chanoine weir, 245 ft., with two piers, would cost only $110 000, a saving of about $70 000 seemed possible by omitting the bear-trap type from this design, the dam to be operated exactly as is done with similar movable dams on the Kanawha River, where success has been attained without the installation of the costly bear-trap weirs. Low-water discharge of the Ohio River at Dam No. 48 was calculated to be 7 160 cu. ft. per sec. Taking 600 ft. as the calculated necessary length of Chanoine weir—no bear-trap weirs to be used—it is found that the remainder of the river can be closed off with a fixed dam of a length of 890 ft., and that its crest can be fixed at 2 ft. below normal upper-pool level. This lowered elevation of the crest of this fixed dam section is such that the ordinary summer and fall discharge will suffice to maintain a full upper pool. However, a design to admit of flash-boards was provided for use under exceptional circumstances of extreme low water. It was also assumed that, at low-water discharge, openings between the pass and weir wickets might be closed with 4 by 4-in. timbers, called "needles". However, to be on the side of safety, it was assumed that there would still be a 1-in. strip of leakage space left between each pair of pass and weir wickets. This assumption gives a low-water loss through the pass of 2 100 cu. ft. per sec., and a similar leakage loss through the Chanoine weir of 1 230 cu. ft. per sec., or a total leakage loss of 3 330 cu. ft. per sec. The remainder of the low-water discharge of 3 770 cu. ft. per sec. would hardly suffice to maintain a full upper pool over the spillway of the fixed dam, but when this unusual condition arose, the flash-boards could be used. The gauge records showed that it would not be necessary to use the flash-boards more than about once in three years.

Further calculations were necessary to determine the maximum discharge that could be passed before it would become necessary to drop the pass wickets.

It was assumed that the dam would be lowered when the upper pool rose to a point 6 in. above the tops of the pass wickets when standing. This pool level would give a depth of 11½ ft. above the Chanoine weir sill and 15.9 ft. above the pass sill. Assuming the accepted design to include 600 ft. of standard Chanoine weir, 800 ft. of navigable pass, and 890 ft. of fixed dam, with crest 2 ft. below normal upper pool, calculation showed that the leakage through the pass wickets amounted to 5 000 cu. ft. per sec. and the 6 in. over the pass crest carried 800 cu. ft. per sec., the 600-ft. weir discharged 61 800 cu. ft. per sec., and the 2½ ft. over the fixed dam spillway carried off 11 000 cu. ft. per sec., or a total discharge of 78 600 cu. ft. per sec. passed the site, which corresponded to an open-river stage of more than 9 ft. above low-water level. This being the condition for which the test calculations were being made, the design seemed satisfactory as it would permit ordinary rises—to somewhat above 9 ft.—to be passed without throwing the main part of the dam and losing the pool. This feature becomes important when one considers what it means to dams farther down stream to be suddenly deluged by the great volume of water released, and also one must consider the many tributaries of the Ohio, which frequently have local rain storms and furnish small floods in themselves, which could be taken care of at the dams on the Ohio without losing the upper pool.

Mr. Hall's suggestion of giving to certain railroads, crossing the Ohio River, the exclusive privilege of operating feeder barge lines on the river, might show up well for the railroad tonnage for the particular road involved and might make the river busier, but it would justly arouse strong opposition from the competing railroads, and would introduce a new element in the rate situation under the supervision of the Interstate Commerce Commission, which rate situation already is sufficiently complicated.

Mr. Hall's statement on page 8* that "Unfortunately, neither the Engineer Department, nor other Government agency, manages or seriously concerns itself with any part of the transportation problem other than the preparation of a sufficient waterway", is open to discussion. Before Congress adopts any river and harbor project, such as the canalization of the Ohio, elaborate preliminary examination and survey reports are made to cover in detail every phase such as "what is desired by local interests", "proposed plans to carry out the improvement", full investigation of "terminal facilities", the "local co-operation" offered, financial or otherwise, full "commercial statistics" of the locality, "local benefits" to be expected, and "general or national benefits" to be expected. These reports by District Engineers pass through the Division Engineer and the Board of Engineers for Rivers and Harbors, each of whom makes full analyses of the District Officers' reports, visits the locality, holding necessary public hearings, and finally the reports pass the Chief of Engineers, U. S. A., who makes his own review and transmits the data through the Secretary of War to the proper committee in Congress, with definite recommendations based on every phase of the transportation situation in the locality.

* *Proceedings*, Am. Soc. C. E., January, 1922.

Recently, the Engineer Department transmitted to Congress a report of 2 400 pages, fully illustrated, with large detail maps, on "Water Terminal and Transfer Facilities" of the harbors of the United States. This is one of the most comprehensive documents ever published and shows what great importance is attached to the matter of terminals, as distinguished from the waterways leading to them. Similar elaborate investigations have been made of the rail facilities leading to the ports, the tributary territory, the terminal charges, etc.

The Interstate Commerce Commission is fully empowered to regulate interstate rates by water as well as by rail, and it frequently refuses to grant requests for reductions in rates, as well as increases. Here, seems to lie the agency for protection against "cut-throat" competition.

The is no doubt but that the Federal Government could force a greater use of its rivers by the grant of exclusive privileges, seizure or confiscation of certain rail lines, or arbitrary changes in freight rates, but it is hardly to be supposed that the situation warrants such action. There are many good reasons why, in the United States, commerce should be permitted to seek its own routes irrespective of whether the Federal Government has a substantial investment in waterways, some of which may not be making a satisfactory tonnage showing. What would the situation be if the waterways had been improved at the expense of private capital, which always demands interest and return of the original investment? This problem looms large to the rail carriers and their security holders.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PAPERS AND DISCUSSIONS

SIPHON SPILLWAYS

Discussion*

By Messrs. Charles F. Ruff, Edward Wegmann, W. P. Creager, H. F. Dunham, Karl R. Kennison, Joel D. Justin, H. B. Muckleston, and Charles G. Darrach.

Charles F. Ruff,† Jun. Am. Soc. C. E. (by letter).‡—To the many useful and ingenious applications of the siphon, which Mr. Stickney describes in his interesting paper, the writer wishes to add one he saw at a small hydro-electric plant in the French Pyrenees. This plant was equipped with four 3 500-h. p. Pelton wheels, operating under a head of 926 m., or more than 3 000 ft. The water was delivered from the forebay through a pipe line down the mountain side, and it was desired to have an automatic shut-off on this line in case of serious leak or break at the plant. This was accomplished by a siphon, arranged as shown in Fig. 14.

The siphon was started by allowing water to flow through the by-pass, P', until a good flow was established; the gate, G, was then closed and the weight of the water in the penstock caused sufficient vacuum to prime the siphon. Under normal conditions, the hydraulic gradient was somewhat as shown by the solid line, and the water in the free end of the U-tube stood a distance below it, equal to the siphonic head, H_s. When a break occurred, or, for any reason, the flow increased beyond a certain limit, the hydraulic gradient fell to the position shown by the dotted line, and the water in the U-tube dropped correspondingly, admitting air to the siphon and stopping the flow.

The writer does not know whether this siphon was ever called on in an emergency, nor what tests were made to determine its effectiveness.

* This discussion (of the paper by G. F. Stickney, M. Am. Soc. C. E., published in February, 1922, *Proceedings*, and presented at the meeting of the Society on March 5th, 1922), is printed in *Proceedings*, in order that the views expressed may be brought before all members for further discussion.

† With Hazen, Whipple & Fuller, Philadelphia, Pa.

‡ Received by the Secretary, March 6th, 1922.

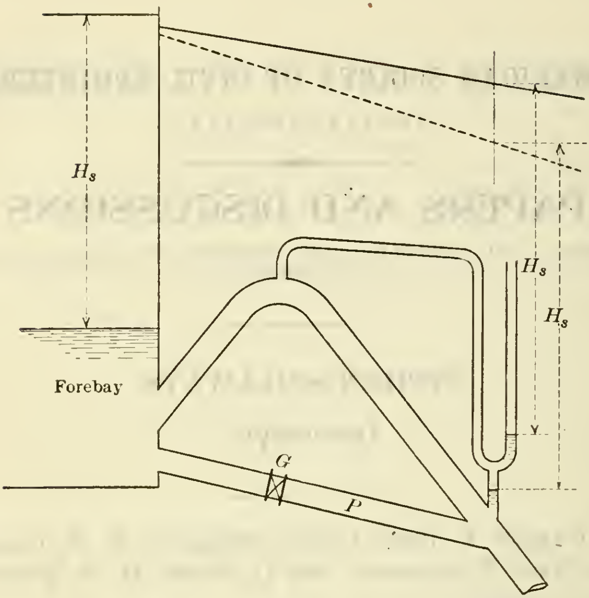

FIG. 14.

EDWARD WEGMANN,* M. AM. SOC. C. E.—The author deserves much credit for an interesting paper on a subject about which little has hitherto been written. He is especially well qualified to discuss this subject, as it was largely through his efforts that siphon spillways were introduced, in 1909, on the New York State Barge Canal, and, afterward, on a number of dams and canals in various parts of the United States.

In Europe, siphon spillways had been built nearly forty years before the advantages of this type of spillway were appreciated in this country. The first siphon spillway, of which the speaker can find any record, was constructed in connection with a dam, at Mittersheim, in Lorraine, France. It consisted of a large vertical pipe, about 2.33 ft. in diameter, having a bend at its upper end. A 6-in. pipe, provided with an ejector, was connected to the bend. As soon as the water in the reservoir rose to its normal level, the ejector came into play and forced the air out of the bend of the large pipe, thus causing siphonic action to take place in the large pipe before the water surface in the reservoir had risen above the top of the bend of the siphon pipe. The use of a small ejector pipe, which was liable to become clogged by débris, was an objectionable feature of this arrangement, and the circular form of the siphon was uneconomical and only practical for siphons of small diameter.

An improvement in these respects was soon made by J. Heyn, of Stettin, Prussia, who was the first engineer to build a siphon spillway without an ejector. This siphon, which was placed on the flood-gate of an irrigation canal in East Prussia, was made of riveted sheet iron, and was 1½ by 10½ ft. in cross-section. It operated under an available head of 4¼ ft., and showed an efficiency of about 50 per cent. The priming is effected by the flow of water over the

* Cons. Engr., New York City.

lower surface of the crest of the siphon, which draws quickly, by friction, the air from the upper part of the siphon, and thus causes siphonic action. As soon as the water level is lowered below the air passages, provided at the bend of the siphon, at normal water level, air enters the pipe and siphonic action is broken. The water is drained from the curve at the outlet end through small holes, in order to prevent its being frozen in cold weather.

Almost contemporaneously with Heyn, Gregotti began the building of siphon spillways without ejectors, in Italy, constructing them of reinforced concrete. One of the largest of these is on the Canale di Milano, near Verona. It consists of ten units, each of which has a cross-sectional area of 14 sq. ft. and an available head of 20 ft. These siphons have an efficiency of 41 per cent. Still larger siphon spillways have been built in France, and a number have been constructed in Switzerland, Sweden, and other countries.

The siphon at Gibswil, Switzerland, consists of a $\frac{1}{4}$-in. riveted steel pipe, which tapers from a diameter of 31.5 in. at the upper end to 23.6 in. at the lower end, in order to prevent the column of water from parting under a head of 52.48 ft. Of course, the effective head cannot exceed that due to a vacuum, which is 33.9 ft. at sea level. At the normal surface, the pipe is cut on a horizontal plane and covered by a reinforced concrete hood, which projects 1 m. below the normal water level to prevent the siphon from being clogged by ice in winter. The air holes are narrow slots in the hood at the normal water level of the reservoir.

Mr. Stickney has stated that the first siphon spillways in the United States were built, about 1909, on the New York State Barge Canal, according to his designs. In 1896, however, the late J. James R. Croes, Past-President, Am. Soc. C. E., showed the speaker plans he had developed for a small dam which was to be constructed at Princeton, N. J., to form a reservoir now known as Carnegie Lake. This dam which was built in 1905, consists of piers placed 28 ft. apart, and joined by curtain walls, 4 ft. thick, in which I-beams were placed. The original plans contemplated the use of a siphonic spillway, but owing to the opposition of the Pennsylvania Railroad Company, the interests of which were dominant, Mr. Croes reluctantly abandoned the idea of building a dam with a siphon spillway and submitted other plans.

In 1916, the speaker was consulted by the late W. W. Scranton, President of the Water-Works of Scranton, Pa., about the stability of five dams. These dams were designed by an eminent engineer, the late Alphonse Fteley, Past-President, Am. Soc. C. E. To increase the storage in the reservoirs, the crests of the dams had been raised 3 ft. which caused the line of pressure, when the reservoir was full, to fall a trifle outside of the center third of the profile. This eccentricity was less than that occurring in the profile type, designed by Rankine, who was the first engineer to call attention to the necessity of designing a dam so that the lines of pressure would be within the center third of the profile, in order to avoid tension in the masonry. However, the engineers of the Water Supply Commission of Pennsylvania, insisted that the dams be cut down to their original heights. This might easily have been obviated by constructing a siphonic spillway designed so as to maintain the water at its original normal level. The speaker, with the assistance of Mr. A. G. Hillberg, designed a siphon spillway for the largest of the Scranton

dams. It was to be built, on an inclined plane, in the outer slope of an earth dam, like the Gibswil Dam in Switzerland, but was to be constructed of reinforced concrete instead of metal. The siphon was to consist of five units, each 4 by 6 ft. in cross-section, and was to have a capacity of about 3 600 cu. ft. per sec. This siphon spillway which could have been constructed at a moderate expense, would have been at that time the largest siphon spillway in America. Several siphon spillways had already been built in the United States, and were all operating successfully. For reasons unknown to the speaker, probably as a matter of policy, Mr. Scranton decided to reduce the heights of these dams to their original levels. It proved to be quite an expensive operation, as the dams were built of excellent masonry.

TABLE 5.—SIPHON SPILLWAYS, YUMA PROJECT.

Date.	Siphon number.	Head, in feet.	Theoretical velocity, in feet per second.	Discharge, in Cubic Feet per Second.		Coefficient.
				Theoretical.	Measured.	
July 24, 1912....	4, 5	11.61	27.3	620	484.9	78.3
24, "	4, 5	11.80	27.5	625	479.6	77.0
25, "	3, 4, 5	11.77	27.4	933	693.5	74.3
25, "	3, 4	11.90	27.7	630	443.3	70.2
26, "	3, 5	11.85	27.6	627	505.1	80.5
26, "	3, 4, 5	11.60	27.3	930	663.0	71.5
29, "	A 11	10.65	26.2	1 488	1 043.4	70.4
29, "	1, 2, 4, 5	11.00	26.6	1 205	853.1	71.0
29, "	A 11	10.87	26.4	1 498	1 012.7	68.0
August 5, "	3	11.90	27.7	315	243.3	77.5
7, "	1, 2	11.60	27.3	620	405.0	65.5
7, "	1, 2	11.60	27.3	620	415.0	67.1
8, "	2, 3	11.48	27.2	617	419.3	68.0
8, "	2	11.87	27.6	314	208.0	66.5
19, "	1, 2	10.98	26.7	606	432.5	71.5
19, "	2	11.82	27.6	314	202.0	64.4

TABLE 6.—OBSERVED DEPTH OF WATER OVER LIP TO START SIPHON.*

Tube number.	Outlet submerged 5.35 ft.	Outlet submerged 6.0 ft.
1	0.40	0.55
2	0.35	0.45
3	0.15	0.25
4	0.35	0.45
5	0.40	0.50

* After a number of leaks were closed in Tubes Nos. 1 and 2, they primed at depths about 0.10 ft. less than shown in Table 6. The seal broke in a few minutes when the water surface had dropped about 0.1 ft. below the air valve.

In the Alpine Dam, in California, Mr. Stickney has given an excellent example of the economy that may be effected by the use of siphon spillways. This dam which is 100 ft. in height, is equipped with a siphon spillway, consisting of six units, each 3 by 7.5 ft. in cross-section. This spillway occupies a crest width of 64 ft. in the central part of the dam, and, according to the author, discharges as much water, with a head of 1 ft., as an ordinary overflow weir, 1 140 ft. long, would discharge with the same head. Compare this dam with the famous New Croton Dam, built, 1895 to 1907, to obtain a large storage reservoir for New York City. It forms a masonry wall across the valley, the southern part being the main dam, and the northern part the

overflow weir which is built along the rocky side hill on the north side of the valley, nearly at right angles to the main dam. The main dam and the waste weir are 1 200 ft. and 1 000 ft. long, respectively. The waste channel, excavated in rock along the north side of the valley, is 50 ft. wide at its upper end and 125 ft. wide at its lower end, where it is spanned by a 200-ft. steel bridge, the superstructure of which cost $40 000. The speaker has no doubt that a considerable saving might have been made if this dam had been built straight across the valley, and provided with a siphon spillway at its northern end.

A number of comparatively small siphon spillways have been built by the United States Reclamation Service, and interesting details relative to their construction have been given* by A. T. Mitchelson, Senior Irrigation Engineer. A number of tests made on small models of siphon spillways at the Throop College of Technology in California and at Fort Collins, Colo., are mentioned by Mr. Mitchelson.

The efficiency of some of the siphon spillways built by the U. S. Reclamation Service has been determined. The data for Tables 5 and 6 which give the results of some of these tests, were furnished the speaker by the Director of the Service, A. P. Davis, Past-President, Am. Soc. C. E.

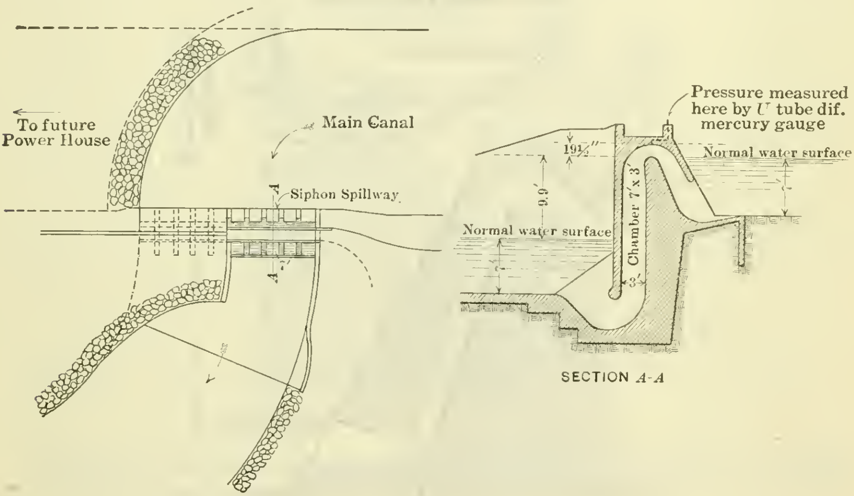

Fig. 15.

The siphon spillway, Fig. 15, on which these tests were made, is on the Yuma Project in Arizona. The first siphon spillways had efficiencies of only about 50% but with modern siphons, this factor, as shown by Table 5, has been increased to 64 to 80% by improvements in construction.

W. P. Creager,† M. Am. Soc. C. E.—The author's excellent paper will be welcomed by all engineers interested in the economical control of the discharge of water from reservoirs. The speaker wishes to discuss several advantages of siphon spillways to which the author, he thinks, has not given full credit.

* "Spillways for Reservoirs and Canals", *Bulletin No. 831,* U. S. Dept. of Agriculture.
† Engr. of Hydr. Structures, The J. G. White Eng. Corporation, New York City.

Mr. Stickney states that the head of water corresponding to the atmospheric pressure is the greatest head that may be utilized for producing siphonic flow. The speaker will endeavor to prove that a head considerably greater than the "siphonic limit" of 33.9 ft. may be used successfully.

For a pipe discharging full, the slope of the hydraulic grade, at any point, varies approximately as the total head on the pipe. The pipe will always remain full if it is tight and the hydraulic grade line, as used in the author's Fig. 1, is above the top of the pipe at all points. If these two laws can be accepted as correct, the siphon indicated in Fig. 1 can be reproduced as shown in Fig. 16, acting under two heads, one of which (like that given by the author) is less and the other greater than the "siphonic limit" of 33.9 ft. The elevation of the hydraulic grade at the entrance to the siphon is the same for the two cases, but the hydraulic grade at the outlet of the longer siphon is below that of the shorter siphon, a distance equal to the difference between the total heads.

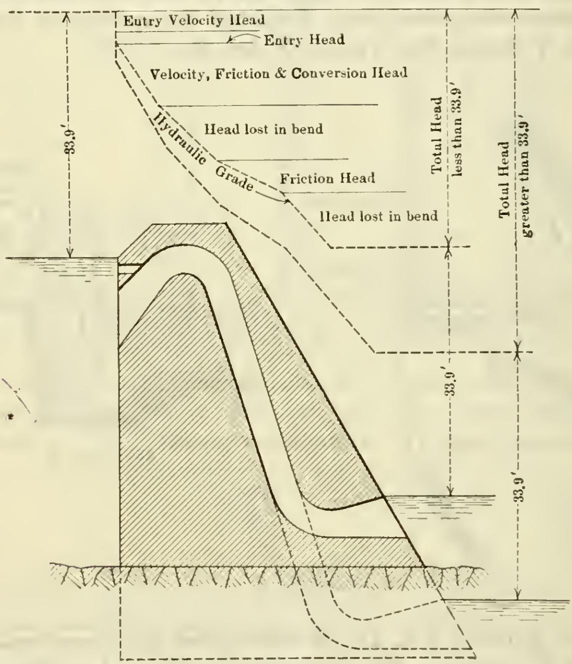

FIG. 16.

As the slope of the hydraulic grade of the long siphon is uniformly greater than that of the shorter siphon, the discharge of the long siphon is the greater if the pipe remains full, and it will remain full if the hydraulic grade is above the top of the pipe. The siphonic limit is reached only when the lower leg is prolonged to such an extent that the hydraulic grade falls below the top of the pipe.

As an example indicating the application of the principles governing the design of siphons, the following is given: In Fig. 17, the head acting on

the siphon is 36.0 ft. The shape and area of the siphon are constant from B to E. The friction loss for a straight pipe is approximately:

$$h_f = k\, l\, v^2$$

For the constant section of this siphon it has been determined from accepted formulas that:

$$h_f = \frac{l\, v^2}{12\,000}$$

The velocity head is,

$$h_v = \frac{v^2}{2\,g}$$

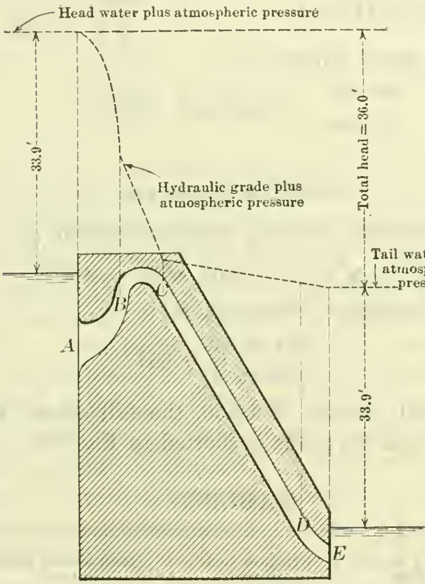

FIG. 17.

The loss at the bends is calculated, according to experiments, in percentages of the velocity head, or,

$$h_b = \frac{p\, v^2}{2\,g}$$

From A to B:

Velocity head $= \dfrac{v^2}{2\,g} = \dfrac{v^2}{64.4}$

Friction head probably about $\dfrac{v^2}{6\,000}$

Head lost at bend $\dfrac{1}{8} \cdot \dfrac{v^2}{2\,g} = \dfrac{v^2}{515}$

From B to C:

Friction head $\frac{8\,v^2}{12\,000} = \frac{v^2}{1\,500}$

Head lost at bend $\frac{0.9\,v^2}{2\,g} = \frac{v^2}{71.6}$

From C to D:

Friction loss $\frac{40\,v^2}{12\,000} = \frac{v^2}{300}$

From D to E:

Friction loss $\frac{5\,v^2}{12\,000} = \frac{v^2}{2\,400}$

Head lost at bend $\frac{0.2\,v^2}{2\,g} = \frac{v^2}{322}$

The summation of these values is:

$$\frac{36.3\,v^2}{1\,000} = \text{total head} = 36.0$$

Therefore,

$$v = 31.50 \text{ ft. per sec.}$$

The theoretical discharge velocity, without friction, is:

$$v' = \sqrt{2\,g\,h} = 8.03\,\sqrt{36} = 48.18$$

The coefficient of discharge, therefore, is:

$$c = \frac{31.50}{48.18} = 0.654$$

Using the calculated velocity of 31.50, the fall of the hydraulic grade is calculated in Table 7 and the grade is plotted in Fig. 17.

TABLE 7.

Section.	Velocity head, in feet.	Friction head, in feet.	Head lost at bend, in feet.	Total head, in feet.
A to B............	15.39	0.16	1.92	17.47
B to C............	.....	0.66	13.83	14.49
C to D......	.....	3.30	.....	3.30
D to E............	.....	0.42	0.32	0.74
....	......	......	......	36.00

The hydraulic grade, for this case, is seen to be entirely above the siphon and the head is not too great for proper operation.

The Ocoee Siphon, indicated in Fig. 8, designed and tested under the speaker's direction, is believed to be the first siphon constructed in the United States, the successful operation of which depended on the time of priming.

The time required to seal and prime the Ocoee Siphon, as indicated by the author in the fifth column of Table 4, is not strictly correct on account of his misinterpretation of the speaker's report of the tests. The time given in

Table 4 indicates the total interval between the cessation of flow at the forebay outlet and the priming of the nearest siphon. As a perceptible interval of time was required for the wave, incident to the stopping of the flow, to pass from the forebay outlet to the siphon, the total time of priming should be corrected accordingly. The correct interval between the start of the rise of the water surface at the siphon, the moment of priming, and the revised calculations necessary to compute the time of priming, according to the author's method, are given in Table 8.

TABLE 8.

Test number.	Elevations of Water, in Feet:		Rise, in feet.	Corrected time, in seconds.	Rate of rise, in feet per second.	Time Required, in Seconds:	
	Low.	High.				To seal.	To prime.
2	1 089.20	1 089.55	0.35	19	0.01843	13.58	5.42
4	"	1 089.57	0.37	14	0.0264	9.47	4.53
5	"	1 089.75	0.55	9	0.0611	4.09	4.91
6	"	1 089.95	0.75	5	0.1500	1.67	3.33

It will be noted that, contrary to the author's deductions, the time required to prime is not constant, but tends to decrease as the rate of rise increases. This seems logical when it is considered that the time required to prime is that required to remove the air trapped in the throat of the siphon. This time is proportional to the average flow during the operation of priming and this average flow increases with the rate of rise of water surface.

The conditions under which the Ocoee tests were made, were such that great accuracy was not possible. The results of these tests, therefore, cannot be used without the application of a considerable margin of safety. Fig. 18 shows the approximate relation between the rate of rise of water surface and the time required to prime, as indicated by the four Ocoee tests.

The curved line drawn through these points is intended to indicate the time of priming of these siphons as nearly as it is possible to determine it from the tests. If the water surface was made to rise suddenly to an elevation considerably above the top of the siphons, it is believed that the time required to prime would correspond approximately to the time required for the water to fall a distance equal to the length of the lower leg, or about 1.25 sec. for a 25-ft. siphon. Therefore, the curve is intended to be asymptotic to a speed of 1.25.

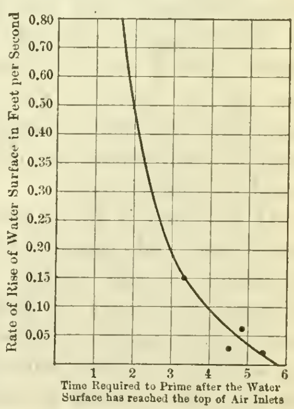

Fig. 18.

In this type of siphon, if the water surface was raised to an elevation just above the top of the air inlets and held stationary, the curve indicates that the siphons would probably prime in about 5.8 sec.

Suppose it is determined from the area of the forebay and the rate of discharge to the turbines that the rate of rise of water surface for full closure

would be 0.3 ft. per sec., then Fig. 18 indicates that the probable time required for the siphons to prime would be 2 sec. Hence, the probable maximum rise of water surface above the top of the air inlets would be $2 \times 0.3 = 0.6$ ft.

However, until such time as more accurate experiments have been made to supplement the speaker's curve, it is believed that at least twice the calculated maximum rise should be used.

Siphon spillways are reliable if designed properly and built where they are not exposed to the danger of being obstructed by trash or ice. They have been used frequently in exposed locations where a failure to operate merely results in inconvenience or the loss of a few flash-boards and where they are not relied on to discharge part of the flood flow. In such cases trash racks may be used to prevent the entrance of logs, trees, or ice, which might clog the siphons and their failure to operate would be only the result of neglect.

They are suitable for the passage of flood flows only at the outlet of large reservoirs where no submerged trash of sufficient size to clog them will reach the dam and where an auxiliary open spillway is provided to pass floating débris and ice. For flood discharge, the siphons should not be provided with trash racks and the throat area should be as large as possible.

The air inlets need constant inspection in cold weather and when trash is running. The speaker knows of one instance where the air inlets became clogged with ice and the siphons drew the water out of the pond and caused the shut-down of the hydraulic turbines. Such instances are rare and may be remedied by an attendant, in a few seconds.

H. F. DUNHAM,* M. AM. SOC. C. E.—Doubtless many engineers will be surprised to learn that so large a number of siphons, of so many varying designs, are in existence. The objects to be gained by their use also are different.

The Tainter gate, it would seem, has certain advantages as a flood-gate. When wide open, the flow is direct, with little opportunity for obstruction. In river channels, the siphon, because of its more intricate passages, might become choked with ice, fences, tree trunks, fragments of buildings, and the like, or, in Southern rivers, with plant-rooted soil, which rises in great quantities and floats, particularly at flood periods. Information about the range of comparative usefulness of the siphon with respect to ice and climate would be appreciated.

If a siphon is in masonry and not metal-lined, small overflows, such as from waves, and especially small leaks through the masonry, would be likely to be frozen in cold weather and thus obstruct or close the opening. The reference to absence of frost in a sewer manhole is not comparable, for the sewer is deep in the earth, contains gases and decomposing substances, and is not subject to cold-air currents. In some of the siphons shown by the author the discharge opening is exposed and, in low-water periods, the siphon would act as a chimney through which currents of cold air would rush with up-stream cold winds. On the down-stream face of large dams, ice, from leakage has formed in large masses and also in mine shafts, at depths of 600 ft., where the

* Civ. and Hydr. Engr., New York City.

rock temperature was above 60° Fahr. caused by the cold air drawn down in ventilation.

Thus, it seems reasonable to inquire how the siphons operate under different conditions, how much attention they need, and whether, for small units, they have advantages over good regulating gates at places where men who have time to attend them, are always on duty. Data on the cost of construction of siphons as compared with cost of gates of older, if not a simpler, type would be valued by the speaker.

Karl R. Kennison,* M. Am. Soc. C. E. (by letter).†—The author has compiled a most valuable collection of data on the siphon spillway. In some of the installations which he has described, the requirements were ideally met by spillways of the siphon type. This is especially true of the various locks and canals. Under certain conditions the siphon spillway is a satisfactory device for controlling the water level of a reservoir or a canal, but it has its limitations and there are some spillway requirements which it cannot meet.

Among the important requirements which the siphon can meet successfully, are: A maximum discharge not to exceed a fairly well determined limit; small fluctuation of reservoir level to be confined to well determined limits in ordinary operation; spillway dam crest to be available for a roadway or other level working area; and available spillway length limited, requiring a high rate of discharge per unit of length.

Some of the important requirements which the siphon cannot meet with safety and economy are: Discharge of flood run-off of uncertain magnitude; provision for the extreme flood, say, once in fifty years, without material rise in reservoir level; certainty of operation in freezing temperature; no possibility of clogging with trash; and remote or inaccessible location with no dependence on periodical inspection.

The author described some installations that are more or less isolated and in locations where freezing temperatures are common; and it would be interesting to know the frequency of inspection required or what measures have been found necessary to insure proper maintenance and operation during the winter.

Ordinarily, the requirements of a spillway to prevent excessive head on, or overtopping of, an important dam cannot be met by the siphon type. There are exceptions, as in the case of the Hetch Hetchy Dam, built to part height, as described by the author. At this dam, it was desired to prevent overflow on account of the roadway. Furthermore, no suitable spillway site can be found at the sides of the steep gorge, until the dam is built to its full height. However, the important point in this case is that it is not essential to prevent overtopping the roadway. If an unusual flood or a clogging of the siphons should cause the water to flow over the top, it would result in only minor damage to the roadway. The concrete arched dam with its gravity section would suffer no damage.

All earth dams and most concrete non-overflow dams are not designed to withstand overtopping in unusual floods. They rely on the spillway to

* Cons. Engr., Boston, Mass.

† Received by the Secretary, March 13th, 1922.

prevent it. Most of the spillways designed by the writer have been primarily safety valves. In each case the degree of safety called for has varied greatly with the circumstances, but, in most instances, greater safety has been demanded than could be furnished by the siphon type of spillway.

The writer has used the siphon spillway in places where its proper operation in every emergency was not essential. In one instance, the requirements were unusual and were successfully met by this type. It was necessary to divert from the reservoir, automatically and without the use of submerged gates, which might leak, a well determined maximum rate of flow fixed by the capacity of the diversion conduit. It was also required to make this diversion at a certain fixed reservoir level and with the least possible fluctuation in this level. As the siphon allows a high rate of flow per unit of length, it was possible to enclose the entire device in a covered screen chamber, conveniently arranged for periodical inspection in all seasons, and thus exclude floating trash and experience little or no trouble from ice. Failure to operate at any time would result in some inconvenience, but no damage to life or property.

It is in such situations just described, that the siphon performs at its best, primarily for convenience and not for safety.

JOEL D. JUSTIN,* M. AM. SOC. C. E. (by letter).†—The advantages of siphon spillways are manifest; the discharge per foot of crest is greater than with an overflow spillway and there is no operating machinery requiring expensive maintenance. It would also seem that, under ice conditions, there would be a great advantage, as the inlet could be located well below minimum head-water level and the outlet below tail-water level.

The author does not state whether it is the usual practice to protect the intake with trash racks. It would be interesting to learn to what extent trash and logs cause trouble in the operation of such siphons, and also to learn what rise in head-water elevation is necessary to prime the largest siphons, such as those at the Sweetwater Dam, shown in Fig. 10.

From Mr. Stickney's description of installations, it appears that it is now practicable to design and build siphons to pass water at the rate of about 120 cu. ft. per sec. per lin. ft. of dam, making due allowance for the necessary walls between the siphons. This places the siphon spillway in a position where it can compete, in the matter of capacity, in many cases, with spillways equipped with Tainter gates. Large Tainter gates, however, have a greater capacity than this, and a spillway equipped with 20-ft. Stoney gates will discharge about 220 cu. ft. per sec. per lin. ft. of dam, and one equipped with 30-ft. Stoney gates will discharge about 400 cu. ft. per sec. per lin. ft. of dam, without any rise in head-water elevation.

However, every device has its limitations, and in cases where it is economical or necessary to pass the largest possible quantity of water over the shortest possible length of crest, some form of spillway gates doubtless, will continue to be the correct solution of the problem.

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* Departmental Chf. Engr., The Ludlow Engineers, Inc., Winston-Salem, N. C.

† Received by the Secretary, March 14th, 1922.

H. B. Muckleston,* M. Am. Soc. C. E. (by letter).†—The design of siphon spillways, or any other hydraulic structure in which the principle of the water barometer is utilized, is not as simple as a casual reading of this paper might lead one to believe.

A point often overlooked in the design of these structures, is the possible effects of dissolved air on their operation. Water that has a free surface in contact with the atmosphere always contains, in solution, a definite proportion of air. The proportion, by weight, varies with the pressure and the temperature but is constant for the same conditions. A diminution of pressure means the instant passage of a definite quantity of air from solution to suspension. The phenomenon is much more striking if the gas is carbon dioxide, as may be observed in a soda-water siphon.

In a true siphon, the water above the inlet contains, in solution, from 1½ to 3%, by volume, of air at atmospheric pressure. This is a true solution, that is, the dissolved air is in liquid form. As the water is accelerated into the inlet, the pressure is reduced to supply the acceleration head and, after passing the inlet, is further reduced by elevation and possibly, also, by acceleration. Air, therefore, is released from solution as the water approaches the crown. As the water is ascending, some of the air may escape from suspension and accumulate at the crown. If some of the atmospheric pressure has been used to create a high throat velocity, the absolute pressure at the crown may be low and the consequent release of air from solution may be great.

At the crown and for some distance on either side, the motion of the water is sensibly horizontal, which facilitates the rising of the bubbles and their release from suspension.

While the water is passing down the discharge leg, the absolute pressure again increases, due to loss of elevation and possibly, also, to negative acceleration; but it may still be less than the saturation pressure for the quantity of air it carries, for a large part of the distance. The air bubbles will tend to rise against the velocity with the chance of further escape and accumulation at the crown. There is, therefore, a possibility of air accumulating at the crown in sufficient volume to stop the action of the siphon unless means are provided for its removal.

In order to be on the side of safety, the hydraulic grade plane should always be calculated through a proposed siphon, making liberal allowances for losses from friction and curvature. From these calculations, the absolute pressure at any point may be determined and the quantity of air released may be estimated. If the investigations show the possibility of "air-binding", an hydraulic ejector or some similar device should be provided to remove the air as it accumulates.

The working head on a siphon is not limited to the barometric height unless the tube is of uniform area throughout. By suitably contracting the

* Chf. Engr., Lethbridge Northern Irrig. Dist., Lethbridge, Alberta, Canada.

† Received by the Secretary, March 20th, 1922.

discharge leg so that the water is continuously accelerated, it is possible to design for differences in level up to 50 ft., or more, and have the tube discharge full bore. The possibility of trouble from air is, however, much increased, and for high working heads the ejector may require more water than the siphon.

The discharge formula given by the author, is useful in fixing tentative dimensions to which more detailed calculations may be applied, but it should not be used to fix final dimensions, unless the tube is of uniform bore throughout; and, even then, the coefficient is a matter of much doubt owing to the losses from curvature and friction. If the cross-sectional area of the tube decreases and increases gradually, the coefficients may be more than unity and even approach 2.0. If the author's formula is applied to the crown area of the siphon shown in Fig. 19, it will be seen that, in this case, the coefficient is 1.7 by calculation and possibly more in reality. Any one having such structures to design will be repaid in reading the chapter on siphons in "The Control of Water", by the late Philip à Morley Parker, M. Am. Soc. C. E., in which one will find that there are pitfalls which may trap the unwary.

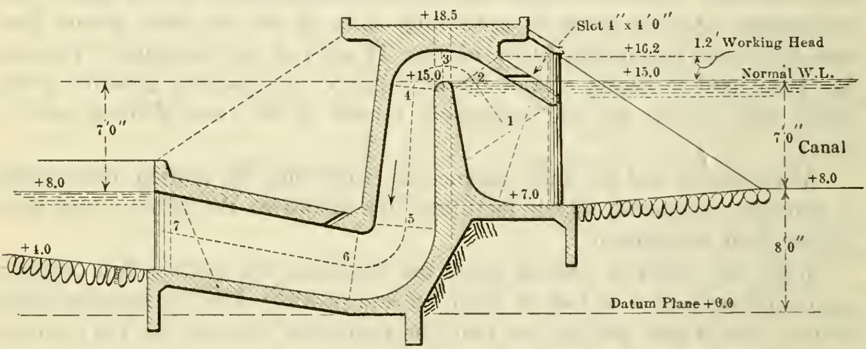

FIG. 19.

Fig. 19 shows a section of a siphon spillway, designed for the main canal of the Lethbridge Northern Irrigation Project, Alberta, Canada. This canal heads in a stream that is subject to rapid fluctuations in discharge. About three miles below the intake is a steel flume with a limited free-board and the siphon was designed to divert any surplus that might enter the canal and overflow the flume. The flume, designed for 800 cu. ft. per sec., might, in emergencies, carry an excess of 150 cu. ft. per sec. The possible fluctuation in 12 hours, in the quantity of water entering the canal might amount to as much as 450 cu. ft. per sec. The spillway was accordingly designed to discharge 300 cu. ft. per sec., under a working rise of 1.2 ft., which corresponds to an excess of 450 cu. ft. per sec. in the canal.

Table 9 shows the calculations for this structure, and is self-explanatory. It will be noted (Line 22) that, at the crown, the water is under a negative pressure of 24.4 ft. of water (center of stream) or 25.4 ft. at the summit;

TABLE 9.—CALCULATIONS FOR SIPHON SPILLWAY.

		1	2	3	4	5	6	7
1	d = Depth, in feet	6.4	2.8	2.0	2.8	4.0	4.5	5.0
2	b = Width, in feet	4.0	4.0	4.0	4.0	4.0	4.0	8.0
3	$A = bd$ = Area, in square feet	25.6	11.2	8.0	11.2	16.0	20.0	40.0
4	$V = \frac{Q}{A}$ = Velocity, in feet per second.	11.7	26.5	37.5	26.7	18.7	15.0	7.5
5	$h_v = \frac{v^2}{2g}$ = Velocity head, in feet	2.13	10.9	21.8	11.1	5.42	3.5	0.90
6	w = Perimeter, in feet	20.8	13.6	12.0	13.6	16.0	17.0	26.0
7	$r = \frac{A}{P}$ = Hydraulic radius	1.23	0.82	0.67	0.82	1.00	1.17	1.54
8	A_1 (mean)	....	18.7	9.6	9.6	13.6	18.0	30.0
9	r_1 (mean)	....	1.03	0.75	0.75	0.91	1.09	1.35
10	V_1 (mean)	....	16.3	31.2	31.2	22.0	16.6	10.0
11	$S = \left(\frac{V}{100\, r^{2/3}}\right)^2$, n (Kutter) = 0.015..	....	.026	0.143	0.143	0.055	0.024	0.007
12	L = length, in feet	....	4.4	2.0	2.5	8.8	4.7	12.7
13	$h_f = SL$ = friction loss in feet	....	0.114	0.287	0.358	0.483	0.113	0.084
14	h_c = loss from curvature, in feet*	....	....	2.39	2.39	....	0.98	....
15	δh	2.1	8.8	10.9	—10.7	— 5.7	— 1.9	— 2.6
16	H = head lost in section = $h_f + h_c + \delta h_v$	2.1	8.9	13.6	— 7.9	— 5.2	— 0.8	— 2.5
17	ΣH = Total head lost, in feet	2.1	11.0	24.6	16.7	11.5	10.7	8.2
18	$\Sigma h_f + c$, in feet	0.0	0.1	2.8	5.6	6.1	7.2	7.3
19	Z = distance above datum, in feet	11.6	15.3	16.0	14.6	5.6	3.2	5.5
20	h_v	2.1	10.9	21.8	11.1	5.4	3.5	0.9
21	$h_v + Z + \Sigma h_f + c = S$	13.7	26.3	40.6	31.3	17.1	13.9	13.7
22	P = Internal pressure, in feet = 16.2—S.	+ 2.5	—10.1	—24.4	—15.1	— 0.9	+ 2.3	+ 2.5

* The values of h_c are as follows:

For Section 2–3, the mean value of $h_v = \frac{10.9 + 21.8}{2} = \frac{32.7}{2} = 16.35$ ft.

For Section 3–4, " " " " $" = \frac{21.8 + 11.1}{2} = \frac{32.9}{2} = 16.45$ ft.

Mean, for Section 2–4 = 16.40 ft.

Total loss = 0.293 h_r = 4.78 ft.

For Section 5–6, the mean value of $h_v = \frac{5.40 + 3.50}{2} = \frac{8.9}{2} = 4.45$ ft.

Total loss = 0.22 h_v = 0.98 ft.

that is, with the water barometer at 29.5 ft., the absolute pressure is only about 4.1 ft. of water. Under the circumstances, and in spite of high crown velocity, air might accumulate at the crown. A hydraulic ejector is provided, therefore, to remove it. This ejector, under a pressure (absolute) of 4 ft. of water, will remove about 10 cu. ft. of air per min., which is more than the probable accumulation.

CHARLES G. DARRACH,* M. AM. SOC. C. E. (by letter).†—An article in *Engineering News*, of March 14th, 1885, on a discussion by the writer of a paper read before the Engineers Club of Philadelphia on February 7th, 1885, includes a description of an automatic siphon weir at Mittersheim, which was designed to discharge large volumes with minimum change of level in the reservoir. This siphon weir which was invented by M. Hirsch, regulated the surface level of the reservoir within 0.03 m. MM. Belard and Hirsch planned

* Cons. Engr., Philadelphia, Pa.

† Received by the Secretary, March 29th, 1922.

and directed the work from 1864 to 1866, which was completed and in operation the following year.

A full description of this siphon weir may be found under the title, "Dam and Syphon Weir of the Reservoir at Mittersheim", in the notices on the models, charts, and drawings relating to the works of the "Ponts et Chaussées" and the Department of Mines, collected by order of the Ministry of Public Works and exhibited in the French collection at the Universal Exposition at Philadelphia, Pa., in 1876.

MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Acting Secretary prior to the final publication.

CHARLES LeROY ANNAN, M. Am. Soc. C. E.*

DIED JANUARY 21ST, 1922.

Charles LeRoy Annan, the son of David E. and Lavina (Roberts) Annan, was born at Lawrence, Mass., on December 25th, 1853. He was of Scotch descent, although his ancestors had lived in New England for several generations.

After having been graduated from Worcester Technical Institute in 1876, Mr. Annan went West, and in November, 1878, began his railroad career as a Rodman on a location survey of the Atchison, Topeka and Santa Fé Railroad. During the next two years, he was engaged with this Company in various capacities as Rodman, Instrumentman, and Assistant Engineer, in the States of Colorado, Kansas, and New Mexico.

In June, 1880, he was appointed Office Engineer of the Sonora Railroad Company, at Hermosillo and Guaymas, Mexico, and after the completion of this road in December, 1882, took charge of the office work of the Chihuahua Division of the Mexican Central Railway Company.

In 1885, Mr. Annan accepted the position of Office Engineer of the Chicago, Burlington and Northern Railway Company, at St. Paul, Minn. In September, 1888, he severed his connection with the Chicago, Burlington, and Northern Railway Company, to go with the Union Pacific Railroad Company at Omaha, Nebr., where he remained until May, 1889. He then returned to St. Paul, and was appointed as Office Engineer in the office of the City Engineer, the late L. W. Rundlett, M. Am. Soc. C. E. Mr. Annan continued in this position, with the exception of about four years, when he returned to railroad work, until March, 1912.

In April, 1912, he again returned to railroad work, this time as Chief Draftsman in the offices of the Great Northern Railway Company at St. Paul. He continued in the employ of that Company as Chief Draftsman and, afterward, as Valuation Engineer, until his death on January 21st, 1922.

He was married on April 30th, 1891, to Mrs. Margaret K. Baylor, who survives him.

Mr. Annan was of a quiet and reserved disposition, and only his closer associates knew of his extremely friendly and charming disposition. He was a conscientious and thorough workman in all matters which came under his charge. Having been a man who loved and cared for his home to the exclusion of public gatherings and public affairs, he found his greatest interest in

* Memoir prepared by George L. Wilson, M. Am. Soc. C. E.

his home life, although he was a member of the Masonic Order and had maintained his membership in the St. Paul Civil Engineers' Society for many years.

Mr. Annan was elected a Member of the American Society of Civil Engineers on July 4th, 1888.

WARD BALDWIN, M. Am. Soc. C. E.*

Died November 15th, 1920.

Ward Baldwin, the son of Henry Ward Baldwin and Ann Esther (Van Ausdol) Baldwin, was born in Shrewsbury, Mass., on March 30th, 1856. In 1860, his parents moved to Cincinnati, Ohio, where his father died shortly afterward.

Early in life, Ward Baldwin showed an aptitude for mathematics and made rapid progress in his studies, having been graduated from the Hughes High School in June, 1874. From there he went to Worcester, Mass., where he was graduated from the Worcester High School, on July 15th, 1875. In the fall of that year, he entered the University of Cincinnati, from which he received the degree of Civil Engineer, and after taking a Post-Graduate Course, he received, on June 18th, 1880, the degree of Master of Science. In June, 1915, his Alma Mater conferred on him the degree of Doctor of Science. In 1883, he was appointed a Trustee of the University of Cincinnati, and served in that position until 1890, when he resigned to accept the chair of Civil Engineering.

During 1881, Mr. Baldwin taught Mathematics and Engineering at the University of Cincinnati, and in the same year he entered the service of the Cincinnati Southern Railroad Company, as Principal Assistant in its Engineering Department, where he remained until 1891.

In the fall of 1891, he returned to the University of Cincinnati, where he served as Registrar until 1896. From 1891 to 1900, he was also engaged as Professor of Engineering at the University, resigning to practice his profession as a Consulting Engineer.

As Consulting Engineer, Mr. Baldwin had charge of the design and construction of some of the largest industrial plants in Cincinnati, and elsewhere in the United States. In this work, he showed such rare inventive genius, ripe knowledge, and fine executive ability, that his services were in constant demand.

On December 5th, 1902, he entered the employ of the Trustees of the Cincinnati Southern Railway Company as Consulting Engineer, and served them efficiently until his death. His work with this Company of constructing and supervising the terminals, viaducts, and bridges, in Cincinnati, evidenced rare skill and unflinching fidelity.

He was still actively engaged in his work as a Consulting Engineer when, after only a brief illness, he died at his home in Cincinnati, Ohio, on November 15th, 1920.

* Memoir prepared by Frank L. Raschig, M. Am. Soc. C. E.

As a writer for engineering publications, Mr. Baldwin's articles on bridge and concrete work placed him in the front rank of men of his Profession, who considered him competent authority on such subjects. His contributions to the *Transactions* of the Society included discussions on the following subjects: "Loadings for Railway Bridges", "Preservation of Railroad Ties", "Railway Bridge Designing" and "Train Loadings for Bridges". He also contributed a paper entitled "Stresses in Railway Bridges on Curves".*

Resourceful, patriotic, and untiring, Mr. Baldwin was ready at all times to serve his city or its university, and gave them his services without stint. It is related that his work in rebuilding the large auditorium for the Saengerfest in 1900, which had collapsed, proved him to be a prodigy. For that service, he was presented with a Gold Medal by Local Societies.

Under his enthusiastic leadership, there was secured from the City of Cincinnati the grant of the site in Burnet Woods Park, where the buildings of the University are now located, and he did much personally toward supervising the erection of these buildings.

Mr. Baldwin followed his profession not merely for the income it brought him, but as a pursuit worthy of his entire mind and heart. He was a fine engineer, holding his profession in the highest regard and insisting on the same consideration for it from all with whom he had to do. He was thoroughly conscientious, incorruptible, energetic, and a hard worker. Although he took an active interest in public improvements, he was most unassuming, and never indulged in display or rhetoric. His life was an example and an inspiration.

Mr. Baldwin was elected a Junior of the American Society of Civil Engineers, on March 2d, 1881, and a Member on October 2d, 1889. Mr. Baldwin was a member of, and the first President of, the Cincinnati Section of the Society, having held that position at the time of his death.

JAMES RICHARD BELL, M. Am. Soc. C. E.†

Died July 14th, 1913.

James Richard Bell was born at Wick, Scotland, on August 21st, 1841, and was educated at Aberdeen University.

He served for a time with an architect in Liverpool, England, and afterward with John Gardiner, a Railway Engineer, in London. After engagements as Assistant and as Resident Engineer on railways in England, Mr. Bell went to Egypt where he was interested in many railway projects.

In 1868, he joined the Indian Public Works Service, in which Service he remained for many years. He was one of the pioneers in railway construction in India, bridging rivers in the north under most adverse circumstances, on which work he was compelled to use untrained and unskilled native labor. He was employed at first in the Madras Presidency, but, later, was transferred to

* *Transactions,* Am. Soc. C. E., Vol. XXV (1891), p. 459.

† Memoir compiled from information furnished by E. Brook-Fox, Assoc. M. Am. Soc C. E., and on file at the Headquarters of the Society.

the State Railways Department of India in which service he remained until his retirement in 1896.

Mr. Bell did excellent work and gained a high reputation in bridge construction. Among the more important of his bridges may be mentioned the Empress Bridge over the Sutlej, the Muttra Bridge across the Jumna, the Ferozepur and the Sher Shar Bridges over the Chenab. He also devised methods for training rivers by means of bunds.

He made many difficult surveys and constructed many miles of railway on the Northwestern, East Coast, Indus Valley, and other Indian Railway Systems, one of his most important services to India having been the construction of the line from Ruk to Bolan, which gave military access to Kabul. This work was accomplished in an exceedingly short time.

Mr. Bell served the Indian Government for several years as Consulting Engineer for State Railways and Harbors. In 1896, his health broken by overwork and the hot enervating climate, he retired from active service and returned to London, England, where, he lived until 1901. He then took up his residence at Ightham, Kent, England, where he died on July 14th, 1913.

He was a man of exceptional energy and ability, stern, but kindly, devoted to duty, and greatly respected. He was the original of the character "Findlayson" in Rudyard Kipling's story, "The Bridge Builders", contained in his "Day's Work".

Mr. Bell was elected a Member of the American Society of Civil Engineers on September 2d, 1896. He was also a Member of the Institution of Civil Engineers of Great Britain.

HARTWELL PRENTICE FARRAR, M. Am. Soc. C. E.*

DIED DECEMBER 16TH, 1921.

Hartwell Prentice Farrar, the son of Josiah P. and Dorcas Whelpley Farrar, was born in Syracuse, N. Y., on July 7th, 1839. His paternal ancestors were early settlers of Connecticut, and his great-grandfather was a Captain in the Revolutionary War. On his mother's side, his ancestors were from Wales and had settled in Vermont.

Hartwell Prentice Farrar received his early education in the public schools of Syracuse, N. Y., and at Syracuse Institute. He was prepared to enter Rensselaer Polytechnic Institute, but his father's death in 1855 compelled him to go to work, at the age of sixteen, in support of the family. Thus, he began an active life which he continued until 1918, when failing health, following an accident, compelled him to retire, although he never lost interest in engineering and kept in touch with affairs until his death.

Mr. Farrar began his engineering career in 1855 as Chainman and Rodman with the United States Deputy Surveyor on the sub-division of townships on the Upper Mississippi River between Crow Wing (Fort Ripley) and Lake

* Memoir prepared by W. S. Caruthers, M. Am. Soc. C. E.

Melacs. He was also engaged on the survey of the La Crosse and Milwaukee Railroad from La Crosse to the Wisconsin River. In 1856 and 1857, he was engaged as Assistant on the preliminary location surveys for the Mississippi and Missouri Railroad (afterward the Chicago, Rock Island, and Pacific Railroad) between Iowa City and Council Bluffs, Iowa, under the late Gen. Grenville M. Dodge, Hon. M. Am. Soc. C. E., Engineer in Charge. In 1857, Mr. Farrar served as Assistant Engineer in charge of a level party on the Illinois River Improvement. He was also in charge of the soundings on this work, under John B. Preston, Chief Engineer, and Joseph W. Trutch, Engineer in Charge, who, later, became Lieutenant Governor of the British possessions at Victoria, B. C., Canada. A report, made in 1863 to the United States Government, on the practicability of making the river and canal a waterway for ships between Lake Michigan and the Mississippi River, was based on this survey.

In 1858, Mr. Farrar was employed as Assistant in charge of a leveling party, with headquarters at Morris, Ill., on changing the levels and locks of the Morris Division of the Illinois and Michigan Canal. He was also engaged on the Fox River Feeder at Dayton, Ill.

In 1858, he went to Colorado Territory where he was engaged in surveying and mining prospecting. He was given a contract to survey and plat the town site of Denver, and had about completed his arrangements to begin the work, when the Pike's Peak mining excitement occurred. He joined the rush to the prospective gold field and gave up the survey of the future city. While in that section of the country, however, he surveyed Boulder City and Arapahoe County, then a part of Kansas, but now in Colorado.

After leaving Colorado, Mr. Farrar settled in Washington County, Illinois, where he was appointed Deputy County Surveyor.

In September, 1861, he enlisted, in Nashville, Ill., in Company D, 48th Regiment of Illinois, for service in the Civil War. He was soon commissioned a First Lieutenant and, later, Captain. He was in action with his regiment at the battle of Fort Donelson and at Shiloh, also known as Pittsburg Landing, Tenn., where he was wounded. He was afterward assigned to duty as Provost Marshal at Memphis, Tenn., and, in 1862-63, was detailed as Engineer Officer in charge of railroad defenses and fortifications on the lines of the Mobile and Ohio and Mississippi Central Railroads. Captain Farrar also acted as Engineer Officer on the staffs of Generals Sullivan, Kimball, Hurlburt, Washburn, and Dana. He served until the close of the war and received his honorable discharge from the Army in the fall of 1865, when he resumed the practice of his profession.

In 1866, Captain Farrar, as he was afterward known, went to St. Paul, Minn., and was engaged for fifteen months as Assistant Engineer on United States river improvements under Gen. G. K. Warren. This work included surveys on the Minnesota River from the Upper Agency to Fort Snelling and on the Mississippi River from St. Anthony to Lansing, Iowa. In 1867 and 1868, he was engaged on the Minnesota River Railroad as Assistant in charge

of the work of location and construction, and, in 1868 and 1869, he served with the Pittsburgh, Fort Wayne and Chicago Railroad on railroad accounting, in the office at Alleghany, Pa.

Captain Farrar then gave up the practice of his profession and went into business in Cleveland, Ohio, where for about a year he had charge of the Erie Grain Elevator. Although successful in this work, the call of his profession was too strong and, in the fall of 1870, he went to Newark, Ohio, where he was engaged as Principal Assistant in charge of location and construction on the Newark, Somerset, and Straightsville Railroad. This work comprised 45 miles with heavy rock and tunnel work.

In 1871, he went to Peru, where he was employed on the construction of the Callao, Lima, and Oroya Railroad, commonly known as the "Meiggs" Railroad. He first had charge as Division Engineer of the Lima Division from Lima to San Bartolome, at the foot of the Andes Mountains, a distance of 55 miles. On the completion of this work, he was assigned to the Varugas Division, but while on the latter, he was taken ill with fever and after being in the hospital for several weeks, was granted a leave of absence and returned to his home in Jackson, Tenn., in 1872.

From 1872 to June, 1886, Captain Farrar was in the employ of the Mississippi Central Railroad, later re-organized as the Chicago, St. Louis, and New Orleans, which became a part of the Illinois Central System about 1882. In 1872, the main line extended from New Orleans, La., to Jackson, Tenn. In that year, it was decided to build north to Cairo, Ill., and connect with the southern terminus of the Illinois Central. Captain Farrar was employed on this work as Engineer in charge of construction, until the completion of the extension. He was then placed in charge as Engineer of the line from Cairo to New Orleans.

From 1881 to 1886, he was occupied chiefly in the location and construction of branch lines of this Company, under the charter of the Yazoo and Mississippi Valley Railroad. He had charge of the line built from Jackson, Miss., through Yazoo City, north to a connection with Memphis. He made many surveys for branches and line revisions and improvements for the Company.

In June, 1886, he resigned his position with the Illinois Central Railroad to engage in the construction of railroads as a Contractor. He was so occupied until 1889, when he was appointed Chief Engineer of Maintenance on the Mobile and Ohio Railroad. He remained with this Company until 1900, when he resigned to engage in private practice as a Consulting Engineer.

During the time he was with the Mobile and Ohio Railroad, he had charge, as Chief Engineer, of the location and construction of its Montgomery, Ala., line, an important connection about 200 miles in length. He was also engaged on important work, in connection with the Illinois Central Railroad, in an entrance to Cairo, Ill., for the Mobile and Ohio Railroad.

Captain Farrar was engaged in private practice from 1900 to January, 1918, when failing health forced him to retire. During this period, he was very active in his profession, having had charge of surveys and having made reports on

many proposed railroads, including the one from Memphis, Tenn., to Pensacola, Fla. He was also occupied with surveys and construction of highways, municipal improvements, and drainage canals, his work taking him into many States of the South and also to Wyoming.

In June, 1921, he was appointed by the Governor of Tennessee as a delegate to the National Drainage Congress held at St. Paul, Minn., but his health would not permit him to serve.

Captain Farrar was married, in 1863, to Miss Agnes Wilson of Jackson, Tenn., who, with a daughter, Mrs. George Mamer, survives him.

He was a member of the Protestant Episcopal Church for the greater part of his life and for many years was a Vestryman of St. Luke's Church, Jackson. He was a member of the Masonic Order and a Past Grand Commander of the Knights Templar. He was a Charter Member of the Jackson Lodge of Elks. He was always much interested in civic affairs and everything that pertained to the welfare of his community.

Captain Farrar was a man of the highest integrity, was greatly beloved by his friends, and trusted and respected by all with whom he was associated, and no one stood in higher esteem in the community where he had lived since early manhood. He served his country faithfully and was an honor to his profession.

Captain Farrar was elected a Member of the American Society of Civil Engineers on November 1st, 1893.

WILLIAM RYAN HILL, M. Am. Soc. C. E.*

Died June 16th, 1918.

William Ryan Hill, the seventh son of John J. Hill, was born in New York City, on June 21st, 1854. He received his education at St. John's College, Fordham, N. Y., and Tremont Seminary, Pennsylvania.

On the completion of his education, at the age of 18, Mr. Hill immediately obtained a position with the New York Central and Hudson River Railroad, where he advanced so rapidly that in two years he was placed in charge of the elimination of the grade crossings on Fourth Avenue from 115th Street to the Harlem River, in New York City.

For a number of years, Mr. Hill was engaged on the construction of the Elevated Railroad in New York City. He then entered the service of the Boston, Hoosac Tunnel, and Western Railway as Division Engineer in charge of construction. On the organization of the South Pennsylvania Railroad, Mr. Hill was appointed Senior Assistant Engineer and, for three years, he was engaged in making extensive topographic and location surveys in the Alleghany Mountains of Pennsylvania. The surveys made by the Engineering Corps of the South Pennsylvania Railroad for the determination of the final location of the main line, were considered as models for many years.

* Memoir prepared by Frank Sutton, M. Am. Soc. C. E.

In 1889, he was appointed Chief Engineer of the Syracuse Water-Works, and under his supervision the new system of water supply for that city was constructed and operated. It is acknowledged to be one of the most perfect in the United States in all its details, costing more than $3 000 000, yet the aggregate of all payments to the contractors, including extra bills, was within 1% of Mr. Hill's estimate on which the contracts were based. In 1895, the Society awarded him the Thomas Fitch Rowland Prize for a paper* describing the engineering features of this work.

On December 31st, 1899, much to the regret of the officials of the City of Syracuse, he resigned his position to accept the appointment of Chief Engineer to the Aqueduct Commission of New York City. During Mr. Hill's occupancy of this position, plans were perfected for the New Croton Dam, the Jerome Park Reservoir, and other structures of magnitude, on which both the engineering and construction work was dispatched with marked ability. During the period of this duty, his health failed, and he resigned in July, 1903. In accepting his resignation, the Aqueduct Commission complimented him on his zeal, courage, and engineering skill in so successfully carrying on this great work.

On account of poor health, Mr. Hill accepted no active engagements, serving only in an advisory capacity until January 1st, 1907, when he was appointed Special Deputy State Engineer of New York and placed in charge of the construction of the Barge Canal during 1907 and 1908. At this time, he was offered the nomination for State Engineer, but declined as he preferred not to enter the political field.

In 1909, he opened an independent office in Albany, N. Y., and soon acquired a large and important consulting practice which he continued until his death, which occurred at his home there on June 16th, 1918.

In July, 1874, Mr. Hill was married to Miss Bella S. Baxter, of White Plains, N. Y., who survives him. He is also survived by four sons, John J., Joseph B., Edward B., and William R., Jr., and one daughter, Miss Alice R. Hill.

Mr. Hill was a splendid example of American manhood, clean cut, able, persistent, and industrious, and by his fairness, kindness, and generosity, he built himself deep into the affections of a myriad of people who felt proud to call him friend. His fondness for and devotion to his home and family were notable traits in his character.

His advice for success was "that no one can accomplish great things unless he aims at great things and pursues that aim with untiring energy, unflinching courage, and self-confidence."

At one time he was President of the American Water Works Association and of the Albany Society of Civil Engineers. He was also a member of the New England and Central States Water Works Associations.

Mr. Hill was elected a Member of the American Society of Civil Engineers in July, 1891, and was a Director of the Society at the time of his death.

* "The Water-Works of Syracuse, N. Y.", *Transactions*, Am. Soc. C. E., Vol. XXXIV (1895), p. 23.

HIRAM PHILLIPS, M. Am. Soc. C. E.*

Died December 22d, 1921.

Hiram Phillips was born in Boone County, Missouri, on November 9th, 1859, and received his early education in the public schools of that county. Later, he attended the Missouri State University, and was graduated in the Engineering Class of 1880.

His first employment was with the Mississippi River Commission on surveys and construction on the Lower Mississippi. After more than three years of this work, he resigned in 1884 to take a Post-Graduate Course at the University of Missouri in Mining Engineering and Assaying.

Mr. Phillips then secured a commission as District Mineral Surveyor of Colorado, opening an office at Alma, Colo., where, in partnership with Mr. W. W. Powliss, he followed this branch of engineering for about four years. He then returned to Columbia, Mo., where he accepted an appointment as Assistant Professor of Engineering in the University of Missouri. Being an intensely practical man, Mr. Phillips found his eight years in the field and office of inestimable value to him as a teacher. Many practicing engineers to-day can attribute some measure of their successful practice to the common-sense way in which engineering problems were placed before them by Hiram Phillips during their college days.

In 1891, Mr. Phillips moved to St. Louis, where he maintained an office during the remainder of his life. He engaged in general engineering work, but devoted the greater part of his time to the design and construction of water-works and sewerage systems.

In 1901, he was elected President of the Board of Public Improvements of the City of St. Louis for a term of four years. Under the charter of the city at that time, the President of the Board of Public Improvements exercised supervision over the five Departments, the heads of which composed the Board under which all the public work done in the city was designed and executed, namely, the Water, Sewer, Harbor, and Park Departments, Commissioners for the first three being required to be engineers, as was also the President.

During Mr. Phillips' term of office, in addition to the construction being carried on at all times in a city of the size of St. Louis, which required more or less attention from his office, the World's Fair was built, held, and cleared away, all of which entailed a great amount of detailed work on the President and his office, and brought up many difficult questions for settlement. Mr. Phillips' fairness and clean-cut sense of justice brought him through this trying time with credit not only for himself, but for all his associates on the Board.

In 1905, he resumed his private practice, with St. Louis as his headquarters. During his professional life he served about sixty-nine cities and towns as Consulting, Designing, or Constructing Engineer. He was appointed

* Memoir prepared by the following Committee of the St. Louis Section: S. Bent Russell, John T. Garrett, and Edward E. Wall, Members, Am. Soc. C. E.

on many boards and commissions and reported on various projects for many places, among which may be mentioned Denver, Colo., Oklahoma, Okla., Palm Beach, Fla., Kansas City, Mo., Colorado Springs, Colo., and Santa Fe, N. Mex.

Some of the places for which Mr. Phillips designed and built public works are Florence, Colo., Brookfield, Mo., Columbia, Mo., Raton, N. Mex., Mariana, Blytheville, and Walnut Ridge, Ark., St. Charles, Mo., Centralia, Ill., Grand Junction, Colo., and Phœnix, Ariz. The infiltration galleries on the Verde River and the 30-mile pipe line for the new water supply for Phœnix had just been completed, the water being turned on about December 15th, 1921, and, on December 22d, 1921, Mr. Phillips was making a final inspection of the work, which he had fathered from its beginning in 1912, and for which he had acted as Consulting Engineer to its completion, when he met with the fatal accident which caused his death. The automobile in which he was riding overturned and crushed him.

Hiram Phillips was an engineer who applied common sense to all problems to an uncommon degree. He was outspoken in his views and tenacious of his opinions, intensely loyal to his friends, and gifted with the faculty of making and remembering acquaintances. He was a man of great energy, with a restless mind, ever devising means of getting work under way, and continually seeking new and better methods of construction.

In 1885, he was married to Miss Nellie Horine who, with two children, Paul and Elizabeth, survives him.

Mr. Phillips was a Mason, an Elk, a member of the St. Louis Engineers' Club, of the American Water Works Association, of the Monday Club of St. Louis, and of other technical and social societies and organizations.

Mr. Phillips was elected an Associate Member of the American Society of Civil Engineers on January 3d, 1894, and a Member on November 3d, 1897.

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"TENTATIVE PLAN FOR THE CONSTRUCTION OF A 780-FOOT ROCK-FILL DAM ON THE COLORADO RIVER, AT LEE FERRY, ARIZONA." E. C. LA RUE.

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